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REPORT

OF THE

FUEL POLICY COMMITTEE

INDIA
1974

L/P(D)190Mof Energy—1

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ANNEX TABLES AND TECHNICAL NOTES

PROFESSOR S. CHAKRAVARTI,
Member, Planning Commission and
Chairman, Fuel Policy Committee.

PLANNING COMMISSION,
NEW DELHI.
August 22, 1974.

Dear Shri Malaviya,

The Fuel Policy Committee has authorised me to sumbit to you this Report dealing with the policy issues in regard to fuels, covering the period upto 1990-91. You may recall that Part I of the Report (Fuel Policy for the Seventies), submitted to the Government on May 16, 1972, dealt with the Fifth Five Year Plan period only. Subsequent to the submission of Part I of the Report, there have been several changes in the economic situation within the country and in the international situation in regard to the supply and price of oil. The perspective of growth of the economy outlined in the earlier Government documents has been changed to some extent in the Draft Fifth Five Year Plan. The Committee had, therefore, to re-examine several of its previous conclusions and revise its recommendations appropriately. The present Report is based on a comprehensive re-examination of all issues and should be taken as the final Report of the Committee and not as a sequel to Part I.

2. In order to properly plan for meeting the energy demand, it is essential that we assess and forecast the future demand as accurately as possible. The fact that sectors producing energy in primary or secondary forms involve very long gestation periods extending over 5 to 10 years or even longer makes it imperative that we project demand over a 15 to 20 year period for evolving an appropriate energy production plan. In the nature of the case, such a forecast involves that a number of assumptions be made about the rate and pattern of growth of the economy, the technology of energy production and energy utilisation and about possible directional changes in consumer preferences. While in regard to the rate and pattern of economic growth the Committee was guided by the perspective growth of the economy given in the Draft Fifth Five Year Plan, in regard to other factors, the Committee had to make its own judgement based on the study of the past trends in our country, information relating to similarly placed countries and from various published materials regarding possible technological shifts in future.

3. The Committee has given several demand forecasts for different forms of fuels, which take into account feasible inter-fuel substitution possibilities even when the aggregate energy requirement may remain constant. The projection of aggregate energy requirements as well as those pertaining to specific fuel forms must be judged as *dimensional hypotheses* rather than as rigid numbers. The main thrust of the Report and of the deliberations of the Committee has been to evolve an *appropriate policy mix* for the energy sectors for the period upto 1990-91. We are of the opinion that our policy conclusions are likely to remain invariant with respect to a fairly wide range of alternative growth rates, even though specific numerical projections may need to be kept under constant review.

4. In forecasting energy consumption in terms of different fuel forms, it is necessary to take into account possible shifts in technology in different sectors of the economy as well as in the relative costs of different fuels over time. While submitting Part I of the Fuel Policy Committee Report in May 1972, we drew the attention of the Government to the fact that crude oil prices which were once predicted to come down significantly had in fact hardened a great deal during the early seventies. In view of the desire of the oil exporting countries to make the most out of their exhausting assets, it was anticipated that the prices would

further harden unless major new discoveries come up and possibilities of substituting oil by other fuels materialise on a substantial scale. We noted that while there are definite indications in this direction, they were not likely to be decisive in the seventies. As there were strong reasons to believe that energy would pose a serious problem from the balance of payments angle if certain hard decisions were not adopted at the right time, we argued that the maximum effective utilisation of domestic energy resources should form a basic desideratum in designing a national fuel policy. On this basis the Committee suggested various means for substituting coal for oil in areas where on techno-economic grounds substitution was justifiable.

5. These recommendations were kept in view in preparing the Draft Fifth Five Year Plan. The Draft Fifth Five Year Plan indicates a directional change in the pattern of utilisation of different fuel resources, by economically acceptable curbs on the rate of growth of oil consumption while planning for expanded production of coal and electric power.

6. The dramatic increase in the price of oil in October 1973 made it imperative that we re-examine our earlier studies. Studies done by the Fuel Policy Committee in the middle of 1973 on the substitution of coal for oil in different sectors of the economy were made on the assumption that the price of oil would be around $ 5 per barrel by the end of the seventies. This was in keeping with the projections made by noted international authorities with the exception of Professor Adelman, who went to the extent of predicting a fall in prices. It is clear from Adelman's recent study that if the rules of the game in the world oil industry conformed to standard economic criteria as discussed in standard tex books, his conclusions could be defended without violence to data. But it is a major act of abstraction and a somewhat unwarranted one to assume that the oil industry could be treated in isolation from a whole set of socio-political factors. The present energy crisis arises out of a very sudden increase in the price of oil products to levels which were not predicted in any study by any country. The movement of oil prices in the international market itself is an interesting study. Given the dizzy heights to which oil prices have soared today, there is a common tendency to lose sight of a certain perspective. Oil represents one commodity whose price went down steadily over a period of 15 years. For example the market price of light Arabian crude was $ 1.93 per barrel in 1955 and it was $ 1.30 per barrel in 1970. Even in January 1972, it was still lower than the 1955 price. But from then on, it has increased today to over $ 11 per barrel within a period of 24 months. The price upto October 15, 1973, was around $ 3 per barrel only. Can this movement in prices be explained by a sudden spurt of demand or a sudden fall in production? At this stage, it is extremely hazardous to make any guesses in this respect since the problem, as mentioned previously, possesses important characteristics which are not purely economic in nature.

7. While the direction of the change in the energy substitution policies suggested in Part I of the Report is invariant to the likely changes in the price of oil products, the pace of inter-fuel substitution has to be determined with reference to the relative price of fuels. At prices of $ 12 per barrel of oil delivered at Indian ports we find that all the uses of oil except those in the transport sector can be substituted for by indigenous fuel, namely, coal or coal-based energy forms. For example, in the household sector the use of kerosene for lighting can be replaced by electricity. The use of kerosene for cooking can be replaced by coal gas in the case of densely populated urban areas and soft coke in small towns and some rural areas. In industry for all heating requirements coal becomes the preferred fuel. For lifting water, electricity becomes more advantageous relative to diesel oil. In the case of transport, the movement of bulk commodities over long distances by rail becomes preferable to road movement even if the expected volume of traffic is low. But it will not be realistic to assume that oil prices will continue at the present level upto 1990-91 as possibilities of producing oil at a very low cost ranging from 15 Cents a barrel to $ 4 a barrel are available in a large number of countries in the world, given the time to explore for oil and develop the oil fields. It would, therefore, appear that while directionally oil will have to be replaced by other fuel forms, which are more abundant in this country, we have to be extremely careful regarding the type and

extent of substitution that we adopt, especially those involving very major investment outlays.

8. Given the uncertainty regarding the level of oil prices in the future, the areas and extent of substitution of oil by coal will have to be limited to those options whose worthwhileness remains largely unaltered for any probable variation in prices. We believe that the recommendations of the Committee contained in this Report satisfy this criterion. The pace of inter-fuel substitution recommended by the Committee is based on our judgement regarding the gestation periods involved in converting oil using facilities to those using alternate fuels to satisfy the substitution requirements and the organisational constraints in effecting the inter-fuel shifts. The recommendations made are mostly invariant to possible changes in the oil price and are feasible of implementation if they are implemented as a whole, taking note of their inter dependence. The directions in which a coherent fuel policy should move are clearer now than ever before and it will not be prudent to delay the implementation of any of these recommendations, if they are otherwise acceptable, in the hope of possible changes in the supply and price of oil.

9. Our analysis contained in the Report establishes beyond any reasonable doubt that coal should be considered the primary source of energy to the country. The coal resources of India, inspite of the quality being poor and their unevenness in geographical dispersal represent the most valuable and reliable source of energy to the economy. In order that this potential advantage is fully exploited several actions are urgently called for. While the primary knowledge about our coal resources is adequate, detailed information on the nature of the deposits is inadequate and this is proving to be a hindrance to expanding coal production quickly. The arrangements for the transportation of coal have proved to be very much short of our needs and unless an integrated plan for production and its transport are drawn up and synchronised investments are made in coal and transport sectors, there is likely to be severe strains on the energy sector. While several suggestions such as pit head generation of power and production of fertilizer in the midst of coal fields have been made to economize on coal transport, there will still be large demand for coal in places away from the centres of coal production. Transportation by rail by increasing quantities of coal will be unavoidable upto the end of the period considered in the Report. It is, therefore, necessary to examine the techniques and procedures of coal transport and devise ways which will enable the transportation of adequate quantities in the most economic manner. Coal mining methods which will lead to extraction of a larger share of coal in the ground than what is being done now will have to be devised. The methods of beneficiating coal to improve the quality and facilitate their economic utilization will have to be devised. In view of the importance of coal in the energy plans of the country, we have given very detailed consideration to the issues connected with coal production, transport and utilisation and a large number of recommendations have been made in these areas.

10. Our oil resources as known today are very insufficient to meet our needs. But there are some indications that we may find more of oil and natural gas particularly the latter. Every effort should be made to step up such production, on shore as well as off shore, and appropriate surveys in advance using geophysical and other sensing devices should be undertaken—the policies outlined for reducing the rates of growth of oil consumption in future may not require any major revisions. Even countries which are endowed with abundant oil reserves like Iran are canvassing the view that oil should be used as raw material for high value chemicals instead of being burnt as mere fuel. The use of oil for any purpose in the country will have to be decided in future with reference to the price at which we can get alternative fuels to be used in place of oil. It is, therefore, important that the policy measures suggested in the Report for reduction of the use of oil in several sectors should be given urgent attention. The extent to which the use of oil could be reduced was examined by the Committee carefully. The suggestions made are based on the consensus regarding the extent to which such reductions are feasible. They are based to some extent on the subjective judgement of the members of the Committee, regarding the organisational and technological improvements that can be achieved within the appropriate time span to bring about reduction in the use of oil in

sectors which have become accustomed to the use of convenient fuel. If we are faced with more severe balance of payments difficulties in future, it may become necessary to force the pace of substitution of oil by other fuels to rates higher than those indicated in this Report. The specific estimates given in the Report should be treated as "normal" estimates based on the assumption that the overall rate of growth in the economy is going to be according to anticipation contained here. In the short-run, special measures may, therefore, need to be adopted to tide over exceptionally difficult situations.

11. The Committee has endeavoured to integrate the policies regarding fuel and supply of feedstock for fertilizers as fertilizer production will be a very important activity calling for the use of material which could be used as fuel. We are convinced that in future at the relative price of coal and oil assumed in our studies coal should be the primary feedstock for fertilizers in the country. Oil refineries will always have some residual heavy-end products which could be used as a feedstock. It is also felt that a greater use of secondary processing to convert the heavy-end fractions in a refinery to higher value light products will be more rational for us.

12. We have erred on the side of caution in assessing electricity demand as a shortage of electricity will be difficult to remedy by any short term remedial measures. However, in translating the power requirements into capacity for power generation to be created, the Committee has tried to include in its calculations a factor reflecting increased efficiency in the operation of power generation and transmission systems. Electricity is a highly capital-intensive source of energy. A country like ours with a serious shortage of capital can ill afford to neglect the possibilities of capital saving that may be available in the power sector. Taking note of the relative merits of different methods of generation the Committee has suggested that more attention should be paid to hydel power generation in the Sixth Five Year Plan and that nuclear power generation based on thorium-plutonium cycle should be introduced at least in the Seventh Five Year Plan.

13. The supply of fuels to the domestic sector in our country presents a number of special problems. The percentage of non-commercial fuels used in the domestic sector though large is slowly getting reduced. (it will be about 80 per cent in 1978-79 and 60 per cent in 1990-91). Our calculation show that the quantity of non-commercial fuels used which has been increasing gradually over time, will reach a peak during the early years of the Sixth Five Year Plan and will decrease slowing from then on. But the magnitude of firewood used will continue to be so large compared to the availability of the resources that there is likely to be serious repercussions in regard to the conservation of forests and the consequential ecological problems. Informed judgement suggests that the extraction of about 120 million tonnes of fuels from forests as of today is much beyond the level of fuels that could be extracted without serious impairment to our forest wealth. This fact and the divergence between social and private costs of using forests fuels underline the need to take-up measures for supply of increased quantities of commercial fuels at appropriate prices to the poorer sections of the rural community and for increasing the availability of firewood by taking up well-conceived schemes of low cost afforestation. Though the benefits of using cowdung as a manure are well-recognised today, increasing quantities of dung are being used as a domestic fuel. Gobar Gas Plants provide a means of exploiting the fuel as well as the plant nutrient potential of dung and therefore, deserve greater attention. Though the total quantitative contribution of gobar gas plants to the fuel needs of the domestic sector, even on very optimistic expectations, is likely to be limited, the contribution of gobar gas plants to other social benefits like nutrient production and pollution abatement have prompted the Committee to strongly recommend an intensified campaign to popularise the use of gobar gas.

14. The problem of energy supply to rural as well as urban areas has implications for ecology and environmental pollution. Data relating to pollution costs and cost of pollution control are, as yet, meagre in India. The Committee could, therefore, make no specific recommendations in this regard. But it is our hope that as and when the problems of pollution become significant in any area or industry, the specific issues will be examined and appropriate measures taken.

15. We have analysed the possibilities of deriving energy from non-conventional sources like geo-thermal energy, tidal power, solar power, etc. It is felt that the likely contribution of energy from these sources will be insignificant during the period covered by this Report.

16. It is well known that there is a growing imbalance between the resource base of our economy and the drift of modern technological developments in the energy sector as observed so far. The international research and development efforts until recently were directed towards improving the methods of utilisation of fuels and feedstock which were in short supply in the country. Inspite of the new thrust in research and development towards the use of coal and other fuels it is necessary that we should ourselves undertake research and development effort, which would enable a more rational use of our resources. A technology plan has, therefore, been suggested in this Report.

17. The Committee has been fully conscious of the fact that energy is one of the several inputs required to ensure the desired rate of economic growth. The availability of energy is a necessary but not a sufficient condition to sustained economic growth. Economic growth can be achieved only when the availability of energy is matched by adequate supply of other inputs. A meaningful energy plant in the economy should be an intergal part of the national plan reflecting fully its objectives and strategies. The Committee has endeavoured to draw up the recommendations for a coherent energy policy which it considers to be in consonance with the objectives and policies of the government. We have suggested certain organisational arrangements like the setting up of Energy Board which will ensure the integration of energy plan with the national plan not only at the stage of drafting these plans but at every stage of their implementations.

18. The Committee is conscious of the fact that our recommendations are fairly numerous and amongst themselves cover a very wide range of issues. This is of course only natural since the problems pertaining to energy sector are inevitably complex and are often interdependent. We would, therefore, request that our recommendations should be viewed in a coordinated manner. If they are found acceptable, we hope that necessary actions in these areas will be initiated and pursued with utmost expedition.

19. I would like to take this opportunity of expressing my gratitude to members of the Committee who not merely tendered very valuable suggestions in their own areas of specialization but throughout the deliberations kept in view the overall implications of formulating an appropriate energy policy on consonance with our fundamental objectives and constraints. The Committee throughout received very valuable assistance from the Secretariat. I would, however, like to place on record my deep appreciation of the work done by Shri T. L. Sankar, Secretary of the Committee, who brought to bear on the problems his comprehensive grasp of the empirical and analytical aspects of the issues dealt with in the Report and thus contributed in a very substantial measure to the formulation and completion of this Report.

With kind regards.

Yours sincerely

(S. CHAKRAVARTY)

Shri K. D. Malaviya,
Minister of Steel & Mines,
NEW DELHI.

CHAIRMAN AND MEMBERS OF THE FUEL POLICY COMMITTEE ON THE DATE OF FINALISATION OF THE REPORT

1.	**Prof. S Chakravarty**	Chairman
2.	**Dr. M. G. Krishna**	*Member*
3.	**Dr. A. Lahiri**	*Member*
4.	**Dr. Kirit S. Parikh**	*Member*
5.	**Shri V.N. Meckoni**	*Member*
6.	**Shri R. Lall**	*Member*
7.	**Shri Rasiklal Worah**	*Member*
8.	**Shri R. G. Mahendru**	*Member*
9.	**Shri N. Tata Rao**	*Member* (in place of Vice Chairman CWPC)
10.	**Shri N. N. Tandon**	*Member*
11.	**Shri T. L. Sankar**	*Secretary*

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SECRETARIAT OF FUEL POLICY COMMITTEE

1.	Shri T. L. Sankar	Secretary
2.	Shri G. V. G. Raman	*Under Secretary*
3.	Shri Priti Pal	*Senior Research Officer*
4.	Shri S. N. Bhagwan	,,
5.	Shri V. Vikraman	,,
6.	Shri Prakash Chandra	,,
7.	Shri B. K. Sinha	,,
8.	Shri B. R. Bhalla	,,
9.	Shri I. V. Soorma	*Research Assistant*
10.	Shri P. Ramaswamy	,,
11.	Miss Parvesh Chawla	,,
12.	Shri K. R. Jain	,,
13.	Shri C. B. Gupta	,,
14.	Shri R. Chetal	,,
15.	Shri S. N. Bannerjee	,,

EQUIVALENTS AND ABBREVIATIONS

EQUIVALENTS

1 lakh	10^5
1 million	$m=10^6$
1 crore	10^7
1 billion	$b=10^9$
1 lb	1 pound=0·454 Kilogram
1 kg	1 Kilogram=2·205 pounds
1 tonne (metric)	1t=1000 Kg=2205 pounds
1 Kilometre	Km =1000 metres=0·621 miles
1 Kilowatt	KW=1000 watts
1 megawatt	MW=1 millionwatts=1000 Kilowatts
1 Kilocalorie	Kcal=4 British thermal units (approx.)
1 KWh	860 Kcal
1 Kcal/kg	1·8 BTU /lb

ABBREVIATIONS

AOC	Assam Oil Company
BHEL	Bharat Heavy Electricals Limited
BTU	British Thermal Unit
C.E.	Commercial Energy
c.e.	coal equivalent
CFRI	Central Fuel Research Institute (Dhanbad, India)
CPRI	Central Power Research Institute
c.i.f.	cost including insurance and freight
c.r.	coal replacemment
CW & PC	Central Water and Power Commission
DAE	Department of Atomic Energy
DWT	Dead Weight Tonne
ESC	Energy Survey Committee
FBR	Fast Breeder Reactor
f.o.b.	free on board
HSDO	High Speed Diesel Oil
HT	High Tension
Hydel	Hydro electric
IIP	Indian Institute of Petroleum (Dehradun)
JBO	Jute Batching Oil
kWh	Kilowatthour
LDO	Light Diesel Oil
LF	Load Factor
LPG	Liquified Petroleum Gas
LT	Low Tension
LTC	Low Temperature Carbonisation
mcfd	million cubic feet per day
mt	million tonnes
mtcr	million tonnes of coal replacement
mtce	million tonnes of coal equivalent
MTO	Mineral Turpentine Oil
NCAER	National Council of Applied Economic Research
NCST	National Committee on Science and Technology
NPC	National Productivity Council
NSS	National Sample Survey
OIL	Oil India Limited
ONGC	Oil and Natural Gas Commission, Dehradun (India)
OPEC	Organisation of Petroleum Exporting Countries
R&D	Research and Development
RRL(H)	Regional Research Laboratory, Hyderabad (India)

CHAPTER I

INTRODUCTION

The Fuel Policy Committee was appointed by the Government of India in the Resolution No. CI-13(11)/70 dated the 12th October, 1970 of the Ministry of Petroleum and Chemicals and Mines and Metals (Department of Mines and Metals) with terms of reference as follows :—

(a) Undertake a survey of fuel resources and the regional pattern of their distribution;

(b) Study the present trends in exploitation and use of fuels;

(c) Estimate perspective of demand by sectors (in particular the transport, industry, power generation industry and domestic fuel) and by regions;

(d) Study the efficiency in the use of fuel and recommend :—

(i) the outline of a national fuel policy for the next fifteen years;

(ii) a pattern of consumption and measures, fiscal and otherwise, which would help the best use of available resources; and

(iii) the measures and agencies, to promote the optimum efficiency in use of fuel.

1.2. The following were appointed to be members of the Committee :—

1. Shri R. Venkataraman, Member (Industry), Planning Commission—Chairman.
2. Shri M. Dutta Chaudhury, Professor of Transport Economics, Delhi School of Economics, Delhi—Member.
3. Vice-Chairman, Central Water & Power Commission, New Delhi—Member.
4. Dr. M. G. Krishna, Director, Indian Institute of Petroleum, Dehradun—Member.
5. Dr. A. Lahiri, Director, Central Fuel Research Institute, Dhanbad—Member.
6. Shri R. Lall, Managing Director, Bengal Coal Company Limited, Calcutta—Member.
7. Shri B. S. Negi, Member (Exploration), Oil and Natural Gas Commission, Dehradun—Member.
8. Dr. Kirit Parikh, Director, Programme Analysis Group Atomic Energy Commission, Bombay—Member.
9. Dr. B. Ramamurti (Statistician), formerly of ECAFE—Member.
10. Shri K. Vaidyanath, Additional Member (Technical), Railway Board, New Delhi—Member.
11. Shri Rasiklal Worah, President, Indian Colliery Owners' Association, Dhanbad—Member.

Shri T. L. Sankar was appointed as the Secretary of the Committee. All the Members of the Committee were part-time and not paid any remuneration for the Committee's work.

Shri R. Venkataraman resigned the Chairmanship of the Committee and in his place Prof. S. Chakravarty, Member, Planning Commission, was appointed as the Chairman (vide Resolution No. CI-13(11)/70 dated 27-7-1971).

Dr B. Ramamurti resigned on grounds of ill-health.

Dr Kirit Parikh left the Atomic Energy Commission and rejoined the Indian Statistical Institute. He, however, continued to be a Member of the Committee. Shri V. N. Meckoni was appointed as Member of the Committee to represent the Department of Atomic Energy. As Shri Vaidyanath, Additional Member (Mechanical), Railway Board, was transferred from Delhi, Shri H. M. Chatterjee, Member (Mech. Engg.), Railway Board, was nominated in his place. After Shri H. M. Chatterjee retired, Shri N. N. Tandon, Member (Mech. Engg.), Railway Board, took his place. After the nationalisation of coal mines in May 1973, Shri R. G. Mahendru, Managing Director, Central Division, Coal Mines Authority, was appointed a Member (vide Resolution No. CI-13(11)/70 dated 31-1-1973). After Shri A K Ghosh retired from the post of Vice Chairman, Shri N. Tata Rao, Member (Thermal) Central Water and Power Commission, was associated with the Committee. Shri M. Dutta Chaudhary left the country to take a foreign assignment in May 1973 and did not attend any meeting thereafter. Dr. A. Lahiri who took active part in all the meetings of the Committee prior to the last meeting to consider the final draft of the Report could not attend this meeting as he went abroad on an assignment in April, 1974. Shri B. S. Negi retired from the ONGC in April 1974.

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1.3. At its meeting on 25-11-1970, the Committee had set up four Working Groups to study different aspects of the fuel policy such as :—

(i) Energy consumption in the past and estimates of future demands for fuel;

(ii) Trends in the relationship between the level of fuel consumption and the levels of different economic activities;

(iii) Relative costs of different fuels;

(iv) Factors influencing the selection of particular fuels and probable trends in fuel consumption taking note of technological shifts industry-wise;

(v) Designing an Analytical framework.

The different Working Groups were assisted in their work by the Secretariat of the Fuel Policy Committee consisting of the Secretary and Under Secretary (whose services were often available only part-time due to their being drafted for other Government work), 4 Senior Research Officers, 8 Investigators/Assistants, 3 Clerks and 3 Stenographers. The staff of the Secretariat was augmented through the part-time association of the two Consultants for some time. In addition, the Committee received help on specific points from the different Divisions of the Planning Commission and from officers of the National Committee on Science and Technology, Department of Mines and Indian Institute of Petroleum.

1.4. The Committee was originally required to submit its Report within 12 months but due to delays in obtaining staff for the Committee's work and in the appointment of a Chairman after the resignation of Shri R. Venkatraman, the Committee could start its work in earnest only in the latter half of 1971. Since it was felt that the Committee's studies would take time and investment decisions had to be taken urgently by the Government with regard to the Fifth Plan programme in the energy sector, a quick study was made of the "Fuel Policy for the Seventies" and Part I of the Committee's Report covering the period upto 1978-79 was submitted to Government in May 1972. The studies made in that Report were based on the perspective plan for 1978-79 incorporated in the Fourth Five Year Plan. Part I of the Committee's Report has to be viewed with reference to these targets of economic and industrial growth. This Report was considered by the various Departments of the Government concerned in framing the Fifth Five Year Plan proposals.

1.5. It was realised by the middle of 1972-73 that there will be substantial slippages in achievement of Fourth Plan targets and that the perspective for the Fifth Plan envisaged earlier would have to be revised. The Committee, therefore, felt that any studies by it in isolation from the Fifth Plan targets would not be reliable and decided to wait for the Draft Fifth Plan to be finalised by the Government. The finalisation took place in November, 1973.

In the meantime, in order to effect economy in expenditure, the Committee's staff strength was gradually reduced and by 31-8-1973, the whole Secretariat staff had been disbanded. The work was thereafter carried out part time by some of the officers who were earlier in the Secretariat of the Committee but were working full time as officers of the Project Appraisal Division of the Planning Commission and the Department of Mines. The first drafts of the different chapters and the Committee's Report were got ready by the middle of 1973 and were considered by the Committee at its meeting held in June, 1973 and July, 1973. Before these drafts could be revised in the light of the discussions at the Committee's meetings there was significant development in the international oil situation as a consequence of the Middle East conflict in October, 1973. Subsequently, in December, 1973, a further steep increase in oil prices took place as a result of which the estimates regarding the demand for oil products and the policy to be followed with regard to their use had to be revised. The Final Report of the Committee has taken note of the developments in the oil producing countries and their impact in so far as the Fuel Policy of India is concerned and has attempted to suggest a pattern of fuel consumption for the future.

1.6. The Fuel Policy Committee held in all 14 meetings including the first meeting at which the various tasks before the Committee were analysed, 4 meetings for finalising Part I of the Report and 9 meetings for considering the Final Report.

1.7. The studies made by the Committee included inter-alia the following main topics, viz.

(a) Trends in the consumption of different fuels state-wise, industry-wise, its relationship with various economic indicators like national income, industrial production etc.

(b) The projection of total demand for energy and for the different fuels both commercial and non-commercial till 1990-91.

(c) Assessment of the different fuel resources available in the country including energy sources which are yet to be exploited and extent of their availability.

(d) Regional distribution of energy consumption.

(e) Cost of transport of energy in different fuel forms and by different modes of transport.

(f) Relative cost of railway traction.

(g) Cost of production of different fuels.

(h) Relative economics of transporting coal and transmission of energy.

1.8. The optimisation studies made by the Committee included a model which would enable consideration of all the factors simultaneously in working out the levels of supply of different fuels which would minimise the total economics of meeting the demand for fuel and fertilizer. A system study to determine the optimal level of nuclear power generation was carried out. Another specific study made by the Committee at the request of the Department of Mines was regarding the economics of expanding the power station at Neyveli involving the opening of a second mine cut vis-a-vis transporting of coal from Singareni to power station near Madras.

1.9. As mentioned earlier the Committee had a very small Secretariat which functioned effectively for about two years only. The expenditure was kept at minimum by taking up most of the computation work with the help of computer. The expenditure incurred by the Fuel Policy Committee was as follows:—

		Rs.
1. Committee's staff	..	2,18,415·00
2. Travelling allowance to members	..	13,253.00
3. Computor hire charges	..	58,636.00
4. Consultancy charges	..	10,000.00
Total	..	3,00,304.00

Acknowledgements

1.10. Due to various reasons some members of the Committee could not attend all the meetings and effectively participate in the discussion but they were represented effectively by their nominees. Particular mention may be made of the contributions made by Dr Inderjit Singh of the Institute of Petroleum Exploration, ONGC, Dehradum and Shri R. B. Seth of the Railway Board. Besides this some experts who were not members of the Committee participated in all the deliberations of the Committee and made valuable contributions to finalization of the Report. Mention has to be made of the services rendered by Dr P. K. Bhatnagar, Department of Science and Technology, Shri S. K. Bose, Department of Mines, Shri B. N. Baliga and Shri K. K. Sarin and Shri M. R. Kulkarni of the Planning Commission, Smt Lalita Singh, Indian Institute of Petroleum, and Shri Shiralkar of Department of Atomic Energy.

1.11. Besides the Secretary, several officers of the Fuel Policy Committee Secretariat worked very hard even after the Secretariat was disbanded in August, 1973, to finalise the Report. Mention has to be made of the hard work put in by Shri G. V. G. Raman, Under Secretary, Department of Mines, S/Shri Pritipal, I. V. Soorma, P. Ramaswamy, Miss P. Chawla and Shri S. K. Prabhakar, of the Planning Commission. Shri R. K. Bhatia as Consultant had helped in making studies on the optimisation of investments in oil sector. The Committee would like to place on record the sincere gratitude to all these persons.

CHAPTER II

TRENDS IN ENERGY CONSUMPTION

Commercial and non-commercial energy sources

2.1. The most important fact about the energy situation in India is that nearly half of the total energy consumed in the country comes from non-commercial sources. The bulk of the non-commercial supplies is consumed in rural areas and is obtained from vegetable waste products, firewood, and cowdung each of which has better alternative uses from the national point of view. In addition, mechanical energy derived from animal power and manpower used for drawing water and ploughing is also used in significant quantity. No records of the quantum of such utilisation are available. It is, however, doubtless that the share of non-commercial energy in the total energy consumption has been declining over the past two decades.

2.2. A careful analysis of the trends in consumption of energy in the last two decades would provide a good basis for forecasting the energy requirements of the future. As the data on the consumption of non-commercial energy has not been compiled in a systematic manner annually, it has to be computed from certain norms of consumption calculated for different years. We shall start with a detailed analysis of the commercial energy consumption and reserve the analysis of non-commercial energy consumption to the end.

Primary and Secondary forms of Energy

2.3. Commercial energy can be divided into two forms, primary and secondary. The primary forms of energy are those which are used in the form in which they are available in nature, while secondary forms of energy are produced by transformation of the primary forms. In India primary form of energy is provided principally by coal and petroleum products while electricity generated from coal or oil is the principal secondary form of energy. Other forms of primary energy like solar energy and geo-thermal energy have no practical significance at present. A part of electricity is also to be treated as a primary source in-as-much as its production is based on the use of materials which are not themselves fuels. Hydro electricity and nuclear electricity could therefore be considered as primary energy sources. Hydro electricity forms an important component of total electric energy consumed in India, while nuclear electricity is only a small contributory sector so far. The secondary form of energy is principally electricity generated by the use of coal. The oil based electricity generation is quantitatively insignificant. Gas derived from coal or oil is also considered as secondary form of energy. For analysing trends in energy consumption, it is found useful to concentrate on three major categories of energy sources—coal, oil and electricity. An analysis of electricity with respect to different sources of its production is also necessary and this has been dealt with in Chapter IX.

Common unit of measurement of energy

2.4. For purposes of aggregating the quantities of energy obtained from different energy sources it is necessary to adopt a common unit of measurement. Different countries and different agencies have been adopting different common units. Coal equivalent tonne is the most commonly used aggregate measure in various international studies. With the emergence of oil as the major source of energy in developed countries, oil equivalent tonne is being adopted as a common unit in some developed countries. But the United Nations is still using coal equivalent tonne as the unit of measure in the statistics compiled for all countries. Coal equivalent tonne expresses the heat content (kilo calories) of each fuel in terms of the heat content of an average tonne of indigenous coal. The calorific value of Indian coal varies from 6700 kcal/kg in the case of selected A & B Grade coal to around 4000 kcal/kg for upgraded coal. We have used throughout the study, 5000 kcal/kg as the average heat content of Indian coal. As the thermal value of oil products is about 10,000 kcal/kg, one tonne of oil is expressed as 2 coal equivalent tonnes in this measure.

2.5. The Energy Survey Committee* which made the first serious attempt to study the trends in energy consumption had adopted the coal replacement tonne as the common measure. The justification was that the coal replacement tonne gives the amount of coal that would have been needed in the economy if no other source of energy were available. This measure takes note of not only the quantity of heat value available in the different fuels used but also of the varying efficiency in the appliances employed. In other words, the coal replacement measure indicates the amount of coal that would be needed to substitute the other fuels taking account of the efficiencies involved in typical cases of substitution. For example, while the use of one tonne of fuel oil for raising heat in industries can be substituted by the use of two tonnes of coal, the use of one tonne of high speed diesel oil in the

*The report of the Energy Survey of India Committee, Government of India, 1965.

Railways for the same haulage would require 9 tonnes of coal. One tonne of fuel oil will, therefore, be measured as two coal replacement tonnes, while one tonne of HSDO will be measured as 9 coal replacement tonnes. The other method used is to express all the heat value in different fuels in kilo-calories. As the efficiency of the use of coal in different sectors/industries increases over time, the coal replacement ratios should be revised from time to time. In the power sector, for example, the coal replacement ratio will change rapidly over time as a result of the increased efficiency of the boilers used in the modern power plants. But if we change the replacement ratios over time to allow for the increased efficiency of use, the figures in different periods of commercial energy consumption may not be strictly comparable. Therefore, the coal replacement term in this Report is used only for purposes of giving a common measurement for convenience of aggregation and should not be taken as indicating the coal required for replacing a unit of any particular fuel at any given point of time. Such substitution needs in terms of coal will have to be worked out with reference to the sector where substitution is to be attempted and the time at which such substitution will take place. It should be noted that while adopting other aggregate measures like coal equivalent or kilo calorie, for measuring the hydel and nuclear power in terms of the common units of measurement, some consideration of the efficiency of the use of coal or oil in power stations becomes unavoidable. All the available measures for aggregation of energy have this limitation. No one measurement is inherently superior to any other and the choice between different measures will depend on the purposes for which such aggregation of energy consumption is made. For international comparisons it is essential that the measurement should be in coal equivalent terms.

2.6. The Committee has, therefore, given the trends of consumption in coal equivalent terms also. However, as the coal replacement tonne has been used in this country for a number of years and as the various agencies and institutions dealing with energy in India are familiar with this measure, all the discussions in this Report are based on coal replacement tonne. The coal replacement measures used for different energy sources and different products of oil are the same as used in the Energy Survey Committee Report. (See Technical Note II(1)). However, as different products of oil have widely different coal replacement values and as the pattern of use of oil products in the energy sector is changing, the Committee considered it necessary to use the conversion factors of the different oil products separately instead of using the weighted average factor that was adopted in the Energy Survey Committee. The rates of conversion of different measures of energy in their regional units to coal equivalent and coal replacement terms are set out in Table 2·1.

TABLE 2.1

Coal Replacement and Equivalents of Different Fuels

Fuels	Unit	Coal equivalent in m. tonnes mtce	Coal replacement in m. tonnes mtcr
Coal (Coaking 6640 kcal/kg: non-coking coal used in steam generation 5000 kcal/kg)	1 mt	1·0	1·0
Hard Coke	1 mt	1·3	1·3
Soft Coke	1 mt	1·5	1·5
Firewood (4750 kcal/Kg)	1 mt	0·95	0·95
Charcoal (6900 kcal/Kg)	1 mt	1·0	1·0
Oil Products (10,000 kcal/Kg.)			
Black products, (i. e. Fuel Oil, Furnace Oil, Refinery Fuel, LSHS, HHS)	1 mt	2·0	2·0
Kerosene & LPG ..	1 mt	2·0	8·3
HSDO & LDO ..	1 mt	2·0	9·0
Motor Spirit & Jet Fuel	1 mt	2·0	7·5
Natural Gas (9000 kcal/Kg)	$10^9 m^3$	1·8	3·6
Electricity	10^9kWh	1·0	1·0

Total commercial energy consumption

2.7. The consumption of commercial energy during the period 1953-54 to 1970-71 is shown fuelwise in original units and in million tonnes of coal equivalent and coal replacement units in Table 2.2.

TABLE 2.2

Consumption of Commercial Energy in India

Year	Coal (million tonnes)	Oil (million tonnes)	Electricity (billion kWh)	Total commercial energy
A. *In original units*				
1953-54 ..	28·7	3·6	7·6	..
1960-61 ..	40·4	6·7	16·9	..
1965-66 ..	51·8	9·9	30·6	..
1970-71 ..	51·3	15·0	48·7	..
B. *In million tonnes of coal equivalent*				
1953-54 ..	28·7	7·2	7·6	43·6
1960-61 ..	40·4	13·5	16·9	70·8
1965-66 ..	51·8	19·9	30·6	102·3
1970-71 ..	51·3	29·9	48·7	129·9
C. *In million tonnes of coal replacement*				
1953-54 ..	28·7	23·8	7·6	60·1
1960-61 ..	40·4	43·9	16·9	101·2
1965-66 ..	51·8	64·6	30·6	147·0
1970-71 ..	51·3	97·2	48·7	197·2

NOTES :—

(*i*) Details for all the years are given in Annex Table II(1)

(*ii*) Figures of consumption of coal do not include coal used for power generation.

(*iii*) Oil consumption does not include refinery losses and refinery boiler fuel.

(*iv*) The figures of consumption of oil do not include non-energy products such as Lubes and Greases, Bitumen, Naphtha, Petroleum Coke etc. The consumption of such products was as follows :

1953-54 Not available
1960-61 0·5 million tonne
1965-66 1·0 million tonne
1970-71 2·6 million tonnes

The average annual rate of increase in the consumption of commercial energy over the period 1953-54 to 1970-71 was 7.2 per cent. The analysis of the growth in sub-periods shows interesting variations. During the period 1953-54 to 1960-61 the average annual rate of growth of commercial energy consumption was 7.7 per cent between 1960-61 and 1965-66, it was 7.6 per cent; but in 1965-66 to 1970-71 it was only 6.1 per cent.

Fuel-wise consumption

2.8. The percentage shares of different fuels have changed considerably in the last two decades. Table 2.3 sets out the shares of different fuels in the total commercial energy consumption in selected years :

TABLE 2.3

Percentage Share of Different Fuels in Commercial Energy Consumption

Sector	1953-54	1960-61	1965-66	1970-71
A. *In coal replacement terms*				
Coal Direct use)	47·8	39·9	35·2	26·0
Oil (Direct use)	39·6	43·4	44·0	49·3
Electricity ..	12·6	16·7	20·8	24·7
All fuels ..	100·0	100·0	100·0	100·0
B. *In coal equivalent terms*				
Coal (Direct use)	65·8	57·1	50·7	39·5
Oil (Direct use)	16·8	19·0	19·4	23·0
Electricity	17·4	23·9	29·9	37·5
All fuels ..	100·0	100·0	100·0	100·0

The above table shows that the share of coal steadily decreased while the shares of electricity and oil have increased consistently between 1953-54 and 1970-71. The changes in the relative shares of fuels were more rapid during the second half of the Sixties than in the earlier period.

2.9. An analysis of the trends, fuel-wise, indicates that over the period 1953-54 to 1070-71 the average percentage rate of growth of coal consumption has been the lowest at 3.5 per cent per annum while that of electricity has been the highest at 11.5 per cent per annum and that of oil consumption has been at 8.6 per cent per annum. The details of the rates of growth during the different sub-periods of the three principal sources of energy are given in Table 2.4.

TABLE 2.4

Rate of Growth of Commercial Energy Consumption: 1953-54 *to* 1970-71 *and during Sub-periods*

Period	Average annual rate of growth of consumption of			
	Coal	Oil (energy products only)	Electricity	Total commercial energy
1953-54 to 1960-61 ..	5·0	9·1	12·1	7·7
1960-61 to 1965-66 ..	5·1	8·0	12·6	7·8
1965-66 to 1970-71 ..	(—) 0·2	8·5	9·7	6·1
1953-54 to 1970-71 ..	3·5	8·6	11·5	7·2

Sector-wise consumption of commercial energy

2.10. The major sectors of consumption of energy may be divided into the following five, namely; (i) Mining and Manufacturing (ii) Transport (iii) Domestic (iv) Agriculture and (v) Government, Commercial and Others. The consumption of commercial energy in the different sectors for selected years from 1953-54 to 1970-71 is given in Table 2.5.

TABLE 2.5

Sector-wise Consumption of Commercial Energy

(In million tonnes)

Sector	1953-54	1960-61	1965-66	1970-71
A. *In coal replacement terms*				
Mining and Manufacturing	22·4 (37·3)	39·7 (39·2)	60·8 (41·4)	76·3 (38·7)
Transport	21·5 (35·8)	34·2 (33·8)	49·7 (33·8)	64·6 (32·7)
Agriculture ..	1·8 (3·0)	3·6 (3·5)	6·3 (4·3)	9·1 (4·6)
Domestic	12·7 (2·0)	20·8 (20·6)	26·5 (18·0)	35·5 18·0)
Government Commercial & Others	1·7 (2·8)	2·9 (2·9)	3·7 (2·5)	11·8 (6·0)
All Sectors	60·1 (100)	101·2 (100)	147·0 (100)	197·2 (100)
B—*In coal equivalent terms*				
Mining and Manufacturing	19·9 (45·7)	34·7 (49·0)	55·2 (54·0)	68·8 (53·0)
Transport	15·4 (35·3)	22·1 (31·2)	28·1 (27·5)	31·9 (24·6)
Agriculture	0·7 (1·6)	1·7 (2·4)	3·2 (3·2)	5·9 (4·5)
Domestic	5·9 (13·5)	9·4 (13·3)	12·6 (12·3)	16·4 (12·6)
Government Commercial & Others ..	1·7 (3·9)	2·9 (4·1)	3·1 (3·0)	6·9 (5·3)
All Sectors	43·6 (100)	70·8 (100)	102·2 (100)	129·9 (100)

NOTE: Figures in brackets represent sectoral consumption as a percentage of total commercial energy consumption during the year.

2.11. In coal replacement terms the biggest chunk of commercial energy produced goes to the mining and manufacturing sector. The next largest share goes to the transport sector which alongwith the mining and manufacturing sector accounts for over 70 per cent of the total commercial energy consumption in the country. Over the period 1953-54 to 1965-66, the mining and manufacturing sector had been slowly increasing its share in the total commercial energy consumption with a slight set back thereafter while the transport share has been slowly decreasing over time. The share of domestic sector has also been decreasing while the share of the other two sectors has been increasing gradually.

Rates of growth of commercial energy consumption in different sectors

2.12. The average annual rates of growth of energy consumption over the period 1953-54 to 1970-71 in the different sectors were examined. The rate of growth has been 7·5 per cent in the mining and manufacturing sector while it has been 6.6 per cent in the transport sector, 6.2 per cent in the domestic sector and 9.9 per cent in the agriculture sector. However, a sub-period analysis shows that the trends of growth of commercial energy consumption in each sector has been varying in the different periods. The results of the analysis are set out in Table 2.6.

TABLE 2.6

*Sector-wise Rate of Growth of Commercial Energy Consumption during Different Periods**

Sector	Average annual rate of growth of commercial energy (% P.A.) during			
	1953-54 to 1970-71	1953-54 to 1960-61	1960-61 to 1965-66	1965-66 to 1970-71
Mining & Manufacturing	7·5	8·5	8·9	4·6
Transport	6·9	6·9	7·8	5·4
Domestic	6·2	7·3	4·9	6·0
Agriculture	9·9	10·0	12·2	7·5
Government Commercial & Others ..	12·1	7·9	4·9	26·2
All Sectors	7·2	7·7	7·6	6·1

*Calculated with reference to Coal replacement terms.

Sector-wise Fuel-wise trends of consumption of commercial energy

2.13. The percentage share of coal for all the sectors has declined over the last two decades. In mining and manufacturing sector, the percentage share of electricity has increased at a very rapid rate; while that of coal and oil declined—the former at a faster rate. In transport sector, oil took a major share from coal; while he percentage share of electricity did not change appreciably. In the domestic sector, electricity has gained at the expense of coal; while the percentage contribution of oil remained almost stationary. Table 2.7 sets out the sector-wise consumption of commercial energy in quantities and percentages.

TABLE 2.7

Sector-wise Consumption of Commercial Energy (in meter and percentages)

Sector and Fuel	Years			
	1953-54		1970-71	
	(in mtcr)	(in % age)	(in mter)	(in % age)
Mining and Manufacturing	22·45	100·00	76·32	100·00
Coal*	13·8	61·47	31·07	40·71
Oil†	3·65	16·26	10·90	14·28
Electricity	5·0	22·27	34·35	45·01
Transport	21·46	100·00	64·57	100·00
Coal*	12·10	56·38	15·91	24·64
Oil†	8·76	40·82	47·23	73·15
Electricity	0·60	2·80	1·43	2·21
Domestic	12·69	100·00	35·48	100·00
Coal*	2·20	17·34	4·07	11·47
Oil†	9·79	77·15	27·58	77·73
Electricity	0·70	5·51	3·85	10·80
Agriculture	1·81	100·00	9·05	100·00
Coal*	—	—	—	—
Oil†	1·61	88·95	4·51	49·83
Electricity	0·20	11·05	4·54	50·17
Government, Commercial and Others ..	1·70	100·00	11·77	100·00
Coal*	0·60	35·29	0·30	2·55
Oil†	—	—	6·97	59·22
Electricity	1·10	64·71	4·50	38·23

*Exculsive of coal used for power generation.

†Oil products used for energy purposes only.

2.14. The percentage rate of growth of different fuels used in the different sectors are summarised in Table 2.8.

TABLE 2.8

Sector-wise Growth of Consumption of Different Fuels during Different Periods

Sector and Fuel	Average annual rate of growth of consumption during			
	1953-54 to 1970-71	1953-54 to 1960-61	1960-61 to 1965-66	1965-66 to 1970-71
Mining and Manufacturing Sector				
Coal	4·9	6·1	7·6	0·6
Oil	6·6	10·3	2·3	6·1
Electricity	12·0	12·8	14·3	8·7
Transport Sector				
Coal	1·6	4·1	1·6	(—)1·7
Oil	10·4	10·3	12·5	8·6
Electricity	5·2	4·2	7·7	4·3
Domestic Sector ..				
Coal	3·7	3·5	7·9	(—) 0·1
Oil	6·3	7·8	3·9	6·6
Electricity	10·5	11·5	9·5	10·2
Agriculture Sector				
Coal	..	..	..	..
Oil	6·3	7·9	10·0	0·4
Electricity	20·2	21·9	18·8	19·2

NOTE : Residual sector comprising of Government Commercial and Others has not been included in the above table.

Consumption of Non-commercial energy

2·15. Besides commercial energy, large quantities of non-commercial energy, namely, forest fuels, cowdung and vegetable waste, are used in India. A substantial quantity of energy is also contributed by animate energy by bullocks, camels etc. for drawing water or for carrying goods. A certain amount of wind-power is also used by country boats playing in the inland and coastal waters. There is no estimate of animate energy and wind-power consumed in the country. The nature of their uses made it difficult to make any reliable computation of their contribution to the total energy supply. However, some estimates have been made of the contribution to energy supply by firewood, cowdung and vegetable waste. As most of these quantities are not purchased but gathered free of cost from forests and grazing grounds, no record of their usage is kept. Field surveys to assess the extent of quantities used also proved to be unreliable as the vast majority of rural population, who use these quantities have no sense of proper measurement and the subjective assessment of the quantities used lead the field survey to divergent results. (See Chapter X for a detailed discussion).

2.16. The estimate of non-commercial energy in this Chapter is based on the assumptions that the per capita consumption of energy in the domestic sector is 0.38 coal replacement tonne per year and 0.40 coal replacement tonne per year in the urban areas. Based on the estimates of rural and urban population for each year, the total energy consumed in the domestic sector is calculated and the commercial energy consumed in the domestic sector (as given in Annexure II(1)) is deducted to arrive at the total non-commercial energy consumed in this sector. The shares of firewood, vegetable waste and cowdung, calculated on the basis of a survey are 65 per cent, 15 per cent and 20 per cent respectively. We have adopted these for our purpose. The results are set out in Table 2.9.

TABLE 2.9

Consumption of Non Commercial Energy in the Sector

Domestic (Mtcr)

Year	Total non-commercial energy	Firewood	Cowdung	Vegetable waste
1960-61 ..	147·67	95·99	22·15	29·53
1961-62 ..	149·64	97·27	22·44	29·93
1962-63 ..	151·38	98·40	22·70	30·28
1963-64 ..	156·22	101·54	23·43	31·25
1964-65 ..	158·12	102·78	23·72	31·62
1965-66 ..	163·43	106·23	24·51	32·69
1966-67 ..	166·92	108·50	25·04	33·38
1967-68 ..	170·87	111·07	25·63	34·17
1968-69 ..	173·24	112·61	25·99	34·64
1969-70 ..	175·76	114·24	26·37	35·15
1970-71 ..	179·41	116·62	26·91	35·88

2.17. The total commercial energy and non-commercial energy used in the Indian economy during the period 1960 to 1970 in terms of the primary fuels used/coal inclusive of coal for power generation, oil and electricity produced from hydel and nuclear sources and non-commercial energy are summarised in Table 2.10 and 2.11 in original units and in coal replacement measures respectively.

TABLE 2.10

Consumption of Commercial and Non-Commercial Energy (Original Units) from 1960-61 to 1970-71.

Year	Coal in mt*	Oil in in mt** in b.	Hydel and Nuclear kWh*	Fire-wood in mt	Cow-dung in mt	Vege-table waste in mt
1960-61	47·1	6·75	6·57	101·04	55·38	31·08
1961-62	47·4	7·46	8·23	102·39	56·10	31·51
1962-63	57·1	8·39	9·83	103·58	56·75	31·87
1963-64	58·4	8·64	11·55	106·88	58·57	32·89
1964-65	58·7	9·29	12·42	108·19	59·30	33·28
1965-66	64·2	9·94	12·74	111·82	61·28	34·41
1966-67	65·3	10·63	13·86	114·21	62·60	35·14
1967-68	69·2	11·28	15·54	116·92	64·07	35·97
1968-69	68·4	12·66	17·96	118·54	64·98	36·46
1969-70	76·7	13·86	19·41	120·25	65·92	37·00
1970-71	71·1	14·95	22·09	122·76	67·28	37·77

*Coal used for power generation.

**Exclusive of oil products used in no-energy sector.

TABLE 2.11

Consumption of Commercial and Non-commercial Energy from 1960-61 to 1970-71

Year	Total commercial energy	Firewood	Cow-dung	Vege-table waste	Total non-commercial energy	Total energy
1960-61	101·16	95·99	22·15	29·53	147·67	248·83
1961-62	111·98	97·27	22·44	29·93	149·64	261·62
1962-63	126·20	98·40	22·70	30·28	151·38	277·58
1963-64	130·02	101·54	23·43	31·25	156·22	286·24
1964-65	136·47	102·78	23·72	31·62	158·12	294·59
1965-66	146·97	106·23	24·51	32·69	163·43	310·40
1966-67	154·58	108·50	25·04	33·38	166·92	321·50
1967-68	164·61	111·07	25·63	34·17	170·87	335·48
1968-69	176·73	112·61	25·99	34·64	173·24	349·97
1969-70	191·74	114·24	26·37	35·15	175·76	367·50
1970-71	197·19	116·62	26·91	35·88	179·41	376·60

Economic Factors affecting energy consumption

2.18. Since energy is consumed in the process of production of goods and services, one would expect that the consumption of energy in the past would have a close relationship with the overall growth of the economy as represented by the change in national income. As a major portion of the energy consumption in India goes into the Mining and Manufacturing and Transport sectors (the level of activity of the latter in turn being greatly dependent on production in the mining and manufacturing sector), one would also expect a fairly close relationship between the total energy consumption and the index of industrial production or, alternatively, with the income derived from the mining and manufacturing sector. Further, increase in population would lead directly to increase in consumption in the domestic sector. The degree of urbanisation would also affect the consumption of commercial energy in the domestic sector. The other factors that affect the levels of consumption of energy in different sectors are the increasing levels of mechanisation and standards of comforts on the one hand and the improving efficiency in the fuel utilisation on the other. The shift in consumption from one fuel to another would be affected by the relative prices and relative availability of the fuels. With our present state of knowledge, it is not possible to arrive at very meaningful conclusions with respect to the influence exercised in overall energy consumption by the latter set of complicating factors. To give a rough idea of the movement of different factors, the indices of national income, population growth and income from mining and manufacturing sector are set out in Table 2.12 alongwith the indices of consumption of commercial energy over time.

TABLE 2.12

Indices of Energy Consumption and Selected Economic Indices

	1960-61	1961-62	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71
1. Net National Products (1960-61=100)	100·0	103·4	113·5	114·7	125·0	129·2	136·2	142·0
2. Industrial Production (1960-61=100)	101·7	111·2	150·3	152·8	153·6	163·6	175·1	181·5
3. NDP in mining & mfg. ..	100·0	109·0	139·0	140·0	143·0	149·0	157·0	160·0
4. Population (1960-61=100)	100·0	102·1	111·3	113·8	116·3	118·9	121·6	124·3
5. Total commercial energy consumption (excluding Domestic Sector consumption) in coal replacement terms. (1960-61=100)	100·0	110·8	150·0	157·9	169·3	181·1	196·5	201·3
6. Total energy consumption including non-commercial energy in coal replacement terms. (1960-61=100)	100·0	105·1	124·7	129·2	134·8	140·6	147·7	151·2

SOURCE : (1) Economic Survey—1973-74, Government of India.

(2) Calculated from Monthly Statistics of Industrial Production, CSO.

(3) CSO—Estimates of National Product.

(4) Indices constructed with reference to population figures in 1961 and 1971. Population in intermediate years has been projected by suitable interpolation.

2.19. A study of the movement of the different indices indicates that the movements of indices of national income and the indices of total energy consumption (including non-commercial energy) is very closely correlated, while the indices of total commercial energy consumption (excluding domestic sectoral consumption) move very closely with the indices of income from mining and manufacturing sector. The Energy Survey Committee had concluded on the basis of the data relating to the year 1953-54 to 1961-62 that there was close correlation between the growth in the indices of national income and total energy consumption as well as between the indices of industrial production and total commercial energy consumption. The observations relating to the period 1960-61 to 1970-71 reveal that such correlation still continues; the movement of indices of industrial production is not closely correlated to the movement of total commercial energy consumption; but the index of income derived from mining and manufacturing sector is more closely correlated to commercial energy consumption. The rate of growth in consumption of total energy as well as commercial energy was lower during the second half of the Sixties on account of the significantly lower rate of growth of industrial production during the period. Industrial production increased at the rate of 8.1 per cent during the first half of the Sixties but decreased to 3.9 per cent in the second half. The indices of industrial production include mining and major part of the manufacturing sector covered by the Factories Act, 1948; but excludes from its purview production from establishments below the factory level. Besides the usual limitations attaching to the indices of industrial production, the index that is currently used (namely, 1960=100) does not seem to adequately reflect the pattern and growth of the sector during the latter years of the decade of the Sixties due to structural shifts within the sector. Normally, the estimate of income from the mining and manufacturing sector is not considered a very safe explanatory variable as it includes income from small-scale establishments which are computed from scanty data. However, for the purposes of explaining energy consumption, the index of income from mining and manufacturing sector appears to be a more appropriate one.

Regression analysis

2.20. The statistical regression of energy consumption (global as well as sectoral) on the activity levels of the economy as a whole and on the sectoral level was attempted. It was found that there was significant correlation between total commercial energy and national income as well as total commercial energy and income from mining and manufacturing sectors and index of industrial production. The regression models are set out in Technical Note II (2) appended. Regression of total commercial energy on national income gives an r^2 of 0.975 indicating that a high proportion of the total variation in energy consumption is explained by national income. The index of industrial production seems to be the best explanatory variable since r^2 is the highest and the standard error is the lowest, but there seems to be auto-correlation. As national income as an explanatory variable avoids the need to make assumptions regarding sectoral growth rates, it has been used for projecting the future demand for commercial energy.

CHAPTER III

FORECAST OF ENERGY DEMAND

3.1. The level of demand for energy in future would be determined mainly by the pace of economic growth. Factors like changes in inter-sectoral growth rates, efficiencies in the use of energy in different sectors and the shifts in usage due to improvements in technology or due to new technologies within various sectors of the economy would also affect the level of energy demand to some extent. The inherent unpredictability in the latter factors makes the task of forecasting energy demand a hazardous one. While this is so, the long gestation* involved in the energy industries makes it imperative that reasonably reliable predictions of long-term energy demand have to be attempted, if adequate arrangements are to be made to ensure that the required quantity of energy is available. This explains the enormous efforts made in almost all developed countries to periodically forecast long run energy demand.

3.2. Energy demand can be forecast either by an extra-polation of the past trends in energy consumption, or by using regression models which correlate the past levels of energy consumption with the past levels of economic activity or by adopting an "end-use" approach where the energy consumption norms for various categories of consumption are determined and the likely demand for each consumer category in future is computed with reference to the level of activity in each consuming sector consistent with the assumption regarding the overall rate of growth. All the three methods have been used by the Fuel Policy Committee in arriving at a reasonable forecast of energy demand for the period upto 1990-91.

Trend method

3.3. The trend method provides a reliable means of forecasting energy demand only in the case of developed market economies which are in the stage of stable growth. In developing economies where the rates of growth are determined by planning apparatus with a view to bringing about structural changes in the economy, the past levels of energy consumption cannot provide a basis for determining the future levels of demand for energy. In India, at certain times in the past, the rates of growth of consumption of different fuels were constrained by transport availability or the availability of fuels. This implies yet another limitation on the use of the trend method for forecasting energy demand.

3.4. As indicated in Chapter II, the rate of consumption of total commercial energy in India increased by 7.8 per cent per annum during 1960-61 to 1965-66 whereas it declined to 6.1 per cent per annum during 1965-66 to 1970-71. During the same sub-periods, electricity consumption changed from an average growth rate of 12.6 per cent per year in the first sub-period to 9.3 per cent per annum in the second sub-period; in the case of coal, the rate of growth of consumption changed from 5 per cent per annum to (minus) — 0.2 per cent per annum. The part trends like these cannot provide a basis for forecasting energy demand in future years.

Regression method

3.5. In the Indian context regression method which makes use of the observed past relationship between the rate of consumption of energy and other indices of economic growth appears to be a reliable guide to determined the future rates of growth and pattern of consumption of energy. In Chapter II, a survey has been made of the regression models which were studied by the Committee. Though some of the more elaborate multiple regression models are marginally superior in explaining the past data of consumption, these have been discarded for purposes of forecasting as the Committee felt that there are no reliable ways of accurately projecting the various explanatory variables used in these medols. A simple regression model which explains the relationship between energy consumption and national income appears to be, on the whole, more useful as a tool for forecasting energy demand from this one index alone would meter about the future level of economic activity is the desired rate of growth of national income, Committee felt that an attempt to derive the energy demand from this one index alon would have greater acceptability. The Chapter on the perspective of growth of the Indian economy given in the Draft Fifth Five Year Plan sets out the desired rate of growth of national income for the period beyond the Fifth Plan at 6 per cent per annum. The Committee took this as exogenously stipulated and derived the consumption requirements of different fuels and total commercial energy from this by using regression models.

3.6. The regression models used for this purpose are indicated in Chapter II. It may be recalled that the regression equations relating to

*Almost all energy industries have gestation over 4 years; a coal mine or an oil field takes about 4-6 years for its construction development, a thermal plant about 4-5 years, nuclear plant 5-7 years and hydel power station 6-10 years.

consumption of total commercial energy to national income as well as equations which relate the consumption of coal, oil and electricity specifically to national income were considered to be valid and statistically significant.

3.7. The results of these estimates are given in Table 3.1.

TABLE 3.1

Estimate of Demand for Fuels and Total Commercial Energy (1978-79, 1983·84 *and* 1990-91).

(Regression Method) Fig in meter

Year	Coal (Excluding for power generation)	Oil (Excluding non-energy uses)	Electricity	Total commercial energy as estimated by	
				Summatation Cols. 2, 3, 4	Correclation with N. I.
1	2	3	4	5	
1970-71 (Actual)	51·35	97·19	48·65	197·19	197·20
1978-79	95·75	178·58	97·19	371·52	373·00
1983-84	130·68	261·07	145·73	537·48	537·39
1990-91	200·29	425·45	242·46	868·20	871·90

These estimates have been used by the Committee as a check on the estimates obtained by other methods.

End-use method

3.8. In an economy where the rate of growth and the levels of production of different sectors are computed by central planning agencies within an elaborate system of plan calculations it would be more efficient to obtain total energy demand by employing an end-use method based on information relating to norms of energy consumption in physical units. This end-use method sometimes referred to as the "Method of Norms" has been used in many countries for forecasting fuel demands.

3.9. The norms for energy consumption have been calculated with reference to past data and some adjustments have been made to allow for possible shifts in technology and higher levels of efficiency in the use of fuels. The end-use method estimation was done by determining the levels of production in as detailed a manner as possible of the various consumer classes within each sector of the economy. The results are presented in two steps. The first estimates were made in the middle of 1973 based on the following assumptions :—

(a) that the factors which determined the past trend in the level and pattern of fuel usage will continue to operate in future in the same manner;

(b) that the relative prices of fuel will continue to be the same in future as in the past;

(c) that the technology shifts would follow the same trends as in the past.

We have now made some modifications in the norms of usage of different fuels in different industries on account of the anticipated fuel efficiency or shifts in the technology. It was also assumed that the trends in the use of fuel oil for heat raising in the industrial sector would be more in line with the trends observed in periods when there was no severe coal shortage. In other words, the large increases in the use of fuel oil for heat raising noticed in the early seventies on account of the severe shortages of coal were not taken as representing a normal level of usage. The first estimate of fuel demand using the end-use method was obtained by taking into consideration these factors. These estimates are presented as Case-I estimates of demand.

3.10. In October 1973, there was a very sharp increase in the international price of crude. In December, there was a further increase which became effective from 1st January, 1974. (See Chapter VIII—Oil Policy, for an analysis of price trends). As a result of these increases, the price of crude to be purchased for our needs from abroad increased to around $ 10 per barrel on the average even from the year 1974-75; while the previous estimates implied slowly rising prices from the levels obtaining in 1972-73 and reaching a level of $ 5 per barrel by 1978-79. The post-October increase has changed the price of oil products very drastically relative to the current prices of other fuels. This is likely to evoke one or more of the following responses from the consuming sectors :

(i) In certain sectors, the increase in prices may have the effect of decreasing consumption of oil products or goods manufactured from oil products on

account of a significant price elasticity of demand.

(ii) There may be an increase in the efficiency of the use of petroleum products which will lead to the norms of consumption of petroleum products being altered.

(iii) In sectors where petroleum products are substitutable by other fuel forms, there will be a tendency towards an increasing use of other fuels in place of petroleum products.

3.11. The Committee tried to examine these trends and based on such an examination, has drawn two other estimates which can be taken as two alternative levels of fuels demand which may be needed to sustain the same rate of economic growth as in the initial estimate. These have been described as Case-II, Case-III estimates. Together with the initial estimates referred to as Case-I, we have three sets of estimates. The assumptions on which the three alternative estimates have been made are as follows:

Case I—assumptions are as set out in para 3.9 above.

Case II—is an intermediate level between Case-I and Case-III.

Case III—represents the level of fuel demands on the assumption that (i) the level of economic growth upto 1990-91 will be the same as in Case-I; (ii) the relative prices of oil products and other fuels will continue to be the same as in the first quarter of 1974, and (iii) the measures indicated in this Report for increasing fuel efficiency and for substituting oil products by other fuels in areas, which are identified as viable and desirable on techno-economic considerations, are implemented fully by the Government.

3.12. In the following paragraphs, Case-I estimates are first presented in detail with an indication of the basis of the estimates; Case-II and Case-III are stated with details of the fuel efficiency increase and inter-fuel substitution assumed. The combined statements of fuel demand in Case-I, Case-II and Case-III are presented at the end.

Coal demand

3.13. In the end-use method for forecasting the demand for each fuel, the sectors which consume significant quantities of the fuel in question have been selected. Care has been taken to evaluate the consumption norms for each industry with reference to past data and modified wherever necessary, with reference to possible future developments. In deriving the quantities of production anticipated in respect of each industry in different years in the future, we have relied on estimates given in the Chapter of the Draft Fifth Five Year Plan and balances worked out by the Perspective Planning Division of the Planning Commission as well as the Reports of "The Task Forces" which were formed to study the needs of the different industries during the Fifth Plan.*

In the case of coal the following major user categories were examined for determining their specific consumption:

1. Steel Industry.
2. Railways.
3. Electricity (Thermal) sector.
4. Cement Industry.
5. Fertilizer Industry.
6. Paper and Paper Boards Industry.
7. Cotton Textiles Industry.
8. Glass Industry.
9. Jute Industry.
10. Refractories Industry.
11. Sugar Industry.
12. Heavy Chemicals Industry.
13. Brick Burning Industry.
14. Soft-coke Manufacture for domestic use.

3.14. Of these items, 1 to 5, 13 and 14 are more important than the rest in terms of quantities consumed. Steel industry, Railways and power sector between them account for over 60 per cent of the demand. In the case of steel industry, the demand for coal was estimated from the levels of hot metal production required to achieve the levels of finished steel indicated as the desired output level in the Draft Fifth Plan (Vol. I—Chapter I). The estimates also took into consideration the future improvements in the technology of the steel industry and the quantity of coal that would be required and the extent of coal washing needed. (See Annex Table III(1) and Chapter VII for a discussion of this). The Railways will slowly reduce the stock of steam locomotives and the demand for coal for the Railways is estimated from the programme of requirements of steam-locos implied in the Railway plans. These estimates are in agreement with the judgement of the Railway authorities. The demand for coal from the power sector depends on the demand for electrical energy and the likely contribution of electricity from other sources of power generation like hydel and nuclear. The estimate was derived from a study of the power sector as a whole (see Chapter IX). This estimate also took into account the expected increase in the efficiency of use coal in the power sector on account of the large unit size

*These estimates give the production levels in different industries upto 1984-85. For 1990-91, the Committee has made its own assessment of possible production.

and greater efficiency in generating plants to be constructed in future and greater efficiency in the transmission and distribution of power. An estimate of the availability of middlings from the washing programme required to supply the washed coal demand from the steel industry was also made and the full use of the middlings in the power sector was assumed to arrive at the net demand of non-coking coal for power generation. (See Annex Table III(2)). In other words, there is a relationship between the steel demand and the coal demand for power sector implied in these forecasts. If the demand for coal from the steel sector does not pick up as anticipated, it would lead to a reduction in the availability of middlings and consequential increase in the demand for coal from the power sector (provided all other factors remain constant). In estimating the demand for coal as fertilizer feedstock, the likely share of nitrogenous fertilizer production from coal based fertilizer plants was derived from separate studies. (See Chapter VIII on Oil Policy).

3.15 The results of the different studies relating to demand for coal in different sectors is set out in Table 3.2.

TABLE 3.2

First Estimate of Coal Requirements (End-Use Method)

(In million tonnes)

Consuming Sector	Expected requirements in		
	1978-79	1983-84	1990-91
Energy-use:			
1. Steel plants and Coke Ovens (a)	32	53	90
2. Thermal power generation (b)	45	64	118
3. Transport (Railways)	13	11	10
4. Industries	20	27	50
5. Brick burning ..	8	11	20
6. Domestic Soft Coke (a) ..	9	21	30
7. Export	1	2	3
8. Collieries' own consumption	4	6	9
I. *Total* (for energy-use)	*132*	*195*	*330*
Non-Energy use			
9. Fertilizer feedstock (II)	3	6	9
10. Total coal (I+II) ..	135	201	339

NOTES:

(a) In terms of raw coal.

(b) Excluding middlings (5 mt. in 1978-79, 12 mt in 1983-84 and 21mt. in 1990-91) which are included under the demand of steel plant.

3.16. These estimates of demand indicate that of Steel, Power and Railways, the Railways sector will account for 60 per cent of the demand for coal in future. The demand for brick burning and for soft coke is about 12 to 15 per cent of the total demand for coal, but this is a modest estimate and the level of use of coal in these sectors can be higher if there is more production of coal and coal transport capacity is available to move the coal to centres of demand. If the power plant construction and the steel production plans are achieved as per the programme now drawn up and if the rail transport capability is increased adequately, it is reasonable to anticipate that the demands as projected in this Report for coal will materialise.

Oil demand

3.17. In respect of oil, the demand estimate was drawn for each oil-product separately. For each of the oil products a detailed exercise was done to estimate the possible rate of growth either by regression analysis or by end-use methods, depending on the major industry or sector which consumes the specific oil product. The statement below gives the oil products and the major consuming categories:

Oil Product	Consuming industry/category
1. Motor Gas	Motor Gas (Petro) using 4 wheelers, 3 wheelers and 2 wheeler transport vehicles.
2. Aviation Turbine Fuel (ATF)	Jet Engines (Aviation).
3. Kerosene	Domestic Sector
4. High Speed Diesel Oil (HSDO)	Transport Sector/Vehicles using diesel as fuel, irrigation pumps using HSDO
5. Light Diesel Oil (LDO)	Irrigation pumps and stationary generators, power stations, fishing crafts
6. Fuel Oil	Thermal Power Stations, Furnaces and boilers in industries.

3.18 In the case of HSDO, the demand was estimated by regression models relating the consumption of HSDO to income from mining and manufacturing sector. Later these estimates were harmonized with the estimates obtained by end-use method. The total demand for the transport services based on the anticipated level of economic growth were projected and the relative shares of rail and road transport were determined by extrapolating trends observed in the last 10 years. From this, the demand for HSDO was determined. For kerosene, as indicated in Chapter X, the demand was derived on the basis of certain normative assumptions regarding the number of households which would use kerosene for lighting in the rural areas and for cooking in the urban and rural areas. The LDO demand was determined with reference to the past trends and checker for consistency by making an estimate

of the demand from the agriculture sector for use in the number of diesel driven pumps to be set up in the future. Motor-gas demand was projected from past trends with some correction for the possible lowering of demand due to increased price of motor-gas. The use of fuel oil for use in furnace in the industries sector was assumed to be limited by Government policies to levels prevailing in periods when there was no coal shortage. In addition to the estimation of demand for oil products in the energy sector, the demand in other sectors was also studied. The likely extent of use of different oil products, viz. naphtha and fuel oil as fertilizer feedstock were estimated by separate studies using optimisation models.

3.19. The result of the studies are summarised in Table 3.3.

TABLE 3.3

First Estimate of Demand for Oil Products (End-Use Method) (1978-79, 1983-84 *and* 1990-91)

(in million tonnes)

Name of product	1978-79	1983-84	1990-91
I. *Energy Sector*			
1. L. P. G.	0·730	1·200	1·980
2. Motor Gas ..	2·100	2·550	3·360
3. Kerosene	3·400	4·400	6·090
4. A.T.F.	1·500	2·650	6·120
5. HSDO	10·700	15·200	27·910
6. LDO	2·050	2·600	3·700
7. Furnace Oil			
a. Used for power generation and industries	5·500	7·200	10·150
b. coastal bunkers ..	0·230	0·400	0·600
c. International bunkers	0·175	0·350	0·400
8. Others	0·330	0·450	0·700
9. Total (I)	26·715	37·000	61·010
II. *Other than Energy Sector*			
10. Naphtha	3·470	4·270	5·500
11. MTO	0·120	0·200	0·300
12. JBO	0·090	0·100	0·120
13. Fuel oil for feedstock for fertilizer	1·250	2·000	3·000
14. Lubes	0·790	1·000	1·300
15. Bitumen	1·580	2·550	5·000
16. Petroleum coke ..	0·312	0·500	1·000
17. Wax	0·078	0·130	0·250
18. Total (II)	7·690	10·750	16·470
9. Grand Total (9+18)	34·405	47·750	77·480

3.20. In the case of electricity, the future demand was estimated for each consuming class separately. The consuming categories were divided as follows:—

1. Major industries (47 industries which consume 70 per cent of electricity used in industries).
2. Other industries.
3. Domestic sector.
4. Commercial and Government sectors.
5. Public lighting.
6. Traction.
7. Irrigation and dewatering.

In the case of major industries, 47 major users of electricity in the industrial sector, which normally consume over 70 per cent of the electricity, were specifically examined and the electricity demand estimated from the expected levels of production of these industries. The demand for electricity in other industries was estimated with reference to the demand from major industries and the trends in increase of "other industrial consumption". Consumption in the domestic sector and irrigation and dewatering sector was estimated using certain normative assumption regarding the number of power driven rural agricultural pump sets to be set up in different plan periods*. Commercial public lighting was estimated on the basis of past trends. For railways traction, it was estimated on the basis of the level of electrification in the Railways and the stock of electrical locomotives. (This is somewhat larger than the assessment made by the railways). Domestic consumption has been estimated on the basis of the total number of households for 1983-84 and 1990-91 and making the assumption that 50 per cent of the households in 1983-84 and 75 per cent of the households in 1990-91 would be electrified. The average consumption per household has been assumed to be 200 kWh per year.

The results of the estimates are summarised in Table 3.4.

TABLE 3.4

Revised Estimates of Demand for Electricity (1978-79, 1983-84 *and* 1990-91)

END USE METHOD

(billion kWh)

	1978-79	1983-84	1990-91
1. Major Industrial consumption	47·89	80·2	145·0
2. Other Industrial consumpton	20·59	35·5	65·0
3. Total Industrial consumption	68·48	115·7	210·0
4. Domestic consumption	8·68	15·6	25·9
5. Commercial consumption ..	5·58	9·8	21·6
6. Public lighting ..	1·10	2·0	4·4
7. Traction (Railways)..	3·25	5·7	12·6
8. Irrigation and dewatering	10·00	14·2	40·5
9. Total consumption ..	97·09	163·0	315·0
10. Losses and Auxiliary consumption ..	22·77	35·8	70·
11. Total generation required	119·86	198·8	385·0

*During the Fifth Plan period a very major increase in energising irrigation pumpsets is expected with a target of pumpsets to be energised as 2 million new pumpsets. It is assumed that the number of sets to be energised in every Plan period thereafter would continue as in the Fifth Plan.

Adjustments for increased oil prices

3.21. As already indicated, the more than three-fold increase in the international price of crude and oil products has changed the relative price of oil and other fuels. This may lead to either reduction in the consumption of certain oil products due to price elasticity of demand or due to increased efficiency of use of fuels or substituiton of petroleum products by other forms. But the switch over to other fuels in place of petroleum products would not generally be possible in all cases and further would be limited by (a) the availability of other fuels; (b) gestation period involved in increasing production of other fuels to meet the increased demand due to substitution; (c) by the availability of investment funds required to produce the other fuels in place of oil, and the investments required for adopting equipment to use coal and other fuels in place of oil; and (d) relative price of fuels in future.

3.22. Theoretically, it should be possible to calculate the effect of the price increase for each oil product separately—kerosene and motor-gas are the principal petroleum products whose price elasticity of demand may be significant. There are, however, no reliable estimates of price elasticity of demand. It might be questionable also to apply the results of any study on price elasticity of demand made with reference to marginal changes in price to the new situation where the price changes have been very large. It might also be questionable to use any such results for projecting the demand for periods extending over two decades. It is, therefore, not feasible to revise demands on the basis of price elasticity studies.

3.23. On account of the increased price of oil products there is a growing awareness among consumers about the efficiency of use of fuel in general and petroleum products, in particular. Several technical committees have examined the possibility of improving efficiency of fuel use. These committees have held the view that a 10 per cent savings could be effected in the use of HSDO in the transport sector by proper maintenance of vehicles, by adopting fuel calibration systems and by more optimal design of the body of the vehicles and by following good driving practices. We can, therefore, adopt 10 per cent reduction in the total demand of HSDO obtained by using the end-use method as maximum possible reduction due to efficiency of investment in the transport sector. In the case of fuel oil also, increased efficiency is possible by setting simple methods like pre-heating of the furnace oil and by modifications of the burning equipment. Since the estimates have been based on certain measures relating to restricted use of fuel oil, no specific allowance need be made in the estimates of demand for fuel oil which might arise due to more efficient use.

3.24. Inter-fuel substituiton can be predicted with some degree of reliability only when we have relative prices and different technologies that may be available in future for adoption in different sectors. In practice, it is found difficult to forecast any price of oil as the possible long-term price. The estimates of long-term price of crude vary from \$ 4-5 per barrel to \$ 11-12 barrel. We have taken for the limited purpose of assessing the possible substitutions that would take place in the economy, a price of roughly \$ 10 per barrel as the expected long-term price. Even if the realised price exceeds or falls below the \$ 10 per barrel by a certain margin, the substitution possibilities envisaged here would still remain favourable for the national economy. Based on this price, it was found that the most advantageous substitution is in the use of coal in place of fuel oil in furnaces and boilers in industries sector where two tonnes of coal can replace one tonne of oil with minor modifications of the equipment available. It was found that substitution of electricity for energising power sets would be preferable in the use of LDO or HSDO provided the investments for extending the power connections are contained at the present level. The use of soft coke in place of kerosene is also a desirable shift. In the transport sector, moving commodities over long distances by the Railways is more economical than movement by road. The use of coal for production of fertilizer is more economical than the use of fuel oil or naphtha. However, the heavy ends which would be obtained as joint product in the refineries should then be subjected to secondary processing to produce more of light and middle distillates. Even when this is done, certain quantity of residual fuel would be left in seccondary processing which is also fuel oil though of an 'inferior' quality. This inferior oil should be used for fertilizer production. There will therefore be a certain amount of fertilizer production based on the use of fuel oil in each Plan period. (See Chapter VIII on Oil Policy).

3.25 Though all these substitutions are desirable and could be achieved, the institutional and resource constraints will limit the pace of substitution in the near future. We have used our judgement to determine the extent of possible substitution if the best efforts are put forward for achieving the inter-fuel substitutions which are desirable on techno-economic grounds. These levels represent Case-III of the demand estimates. An intermediate level is also forecast which represents achievement of about 50 per cent of the substitution that could be achieved with the best possible efforts. However, even in Case-III, we have not taken into account further savings in oil consumpfion which may be possible, if the composition of industrial production is significantly altered away from energy intensive industries. For doing this, it would be necessary to assume a strategy of industrial growth sharply at variance with our current formulation. Furthermore, we have not assumed the use of administrative machinery—such as

large scale rationing for limiting the consumption of oil products in arriving at our estimate of oil demand. The aggregate oil demand corresponding to Case-III should not therefore be interpreted as representing any sort of a minimum estimate. It represents the likely order of demand that may be expected to materialise, if the appropriate inter-fuel substitutions are pursued vigorously, with product composition and delivery system remaining the same.

3.26. Depending on the efficiency of the efforts taken to achieve the desirable inter-fuel substitution, the demand may lie anywhere between Case-I and Case-III. But Case-II has been presented as a level representing what is possible of achievement under most of the foreseeable set of conditions. In the subsequent chapters relating to the policy issues regarding specific fuels, we refer to Case-II as the normal case. But our recommendations are that efforts should be made to bring the demand in line with the estimates made in Case-III.

The details of the assumptions on which Case-III and Case-II are based, are dealt with sector-wise below.

Domestic sector

3.27. Kerosene is used in the domestic sector for lighting and for cooking. In our first estimates (Case-I) the kerosene demand for lighting is assumed to decrease in future due to the greater use of electricity. But the use of kerosene for cooking increases over time on account of urbanisation and the increasing difficulties in the rural areas to obtain cheaper non-commercial fuels. We have assumed in making the estimates (Case-I) that 25 per cent of the urban households will use kerosene for lighting in 1978-79 and that this percentage will fall to 10 per cent in 1990-91. In the case of rural areas, the kerosene is assumed to be used in 60 per cent of the households in 1978-79 and this get reduced to 25 per cent by 1990-91. For Case-III estimates, the substitution of kerosene by electricity for lighting postulated for 1990-91 is assumed as the level to be reached even by 1983-84. In the case of cooking, the percentage of rural households using kerosene has been assumed to be 10 per cent, 15 per cent and 25 per cent and urban households as 30 per cent, 50 per cent and 70 per cent in 1978-79, 1983-84 and 1990-91 respectively. In the case of cooking, the levels of increased usage assumed for 1983-84 is anticipated to be achieved only in 1990-91. The increased demand for other cooking fuels is assumed to be met by making available greater amount of soft coke. Based on this, the requirements of kerosene are reduced in the domestic sector and an equivalent amount of electricity for lighting purposes and soft coke for cooking purposes is allowed for. Case-II represents an intermediate level between Case-I and Case-III estimates.

Agricultural sector

3.28. In the agricultural sector, HSDO and LDO are used for lifting water by irrigation pumps, and for running tractors and for agricultural machines and equipment. In view of the increased oil prices, there should be a shift from HSDO and LDO to electricity for running irrigation pumps. The other uses cannot be substituted economically. The number of diesel pumpsets in operation is estimated to be 1.5 million in 1973-74 in Case-I estimates. It was assumed that the diesel pumps would increase by 0.5 million pumpsets per year. In Case-III, we assume that the annual increase in diesel pumpsets would only be 0.1 million pumpsets upto 1978-79 and thereafter the stock of diesel pumps will not increase. Case-II is derived as the intermediate level between Case-I and Case-III.

Industrial sector

3.29. The fuel oil used for heat raising can be economically substituted by coal except under very special circumstances and in the case of specific industries. In Case-III we assume that the Case-I estimate of furnace oil will be reduced by a further 25 per cent by a larger number of units now using furnace oil switching over to the use of coal. After 1978-79, an annual increase of 4 per cent per year has been assumed upto 1990-91. Case-II is obtained as the average of Case-I and Case-III.

Transport sector

3.30. In the transport sector, motorgas is used in road transport for private cars, taxis, three wheeler and two wheeler vehicles and a small fraction of commercial vehicles. HSDO is used by commercial vehicles and by the railways. ATF is used for air transport services. Fuel oil is used by inland and coastal ships and international shipping transport. (A small portion of LDO is used in ships and small fishing crafts but it is so small that it has not been separately considered).

As a result of price increase, motorgas consumption has come down steeply in the current year itself. In future the number of cars to be added to the stock every year may decrease slowly. After a few years, the net additions to the stock each year may be less than the additions previously anticipated and the consumption per vehicle is also likely to be less than in the past (as indicated by the consumption level now observed after motorgas price hikes). Taking these into account in Case-III it has been assumed that the rate of growth of motorgas consumption may be 2 per cent per year less than the rate assumed in the original forecast. It may be necessary to resort to fiscal measures to reduce the motorgas demand. Case-II is obtained as the average of Case-I and Case-III.

3.31. In the case of commercial traffic in Case-I, we have assumed a declining trend in the percentage share of the railways in the freight traffic. This was 83 per cent in 1960-61 and also has come down to 70 per cent in 1973-74. Extrapolating the trends, it was assumed in the first

estimates that the freight traffic would be 66 per cent in 1978-79, 62 per cent in 1983-84 and 56 per cent in 1990-91. It has been established that it is economically preferable to transport goods by the railways instead of roadways in the Indian situation where the commodity compositions of the total freight indicates that, even by 1990-91, bulk of the commodities moved will be coal, iron ore and limestone; etc. It has been assumed in Case-III that the percentage share of the Railways in the total freight traffic will remain at 66 per cent from 1978-79 onwards. In view of the current difficulties faced by the Railways, it will be unrealistic to expect a better performance than is assumed in the plan, by the Railways upto 1978-79. It has however verified from the Railways that, given clear indication even now of the magnitude of the task to be performed by the Railways, it will be possible for them to move larger quantities in 1983-84 and 1990-91. In the case of passenger traffic in Case-I a similar assumption of declining trend of the Railways share has been made. In Case-III, it is assumed that Railway share of passenger traffic which will be 50 per cent by 1978-79 will now decline further. Case-II is obtained as the intermediate level between Case-I and Case-III. To the extent the Railways move larger quantities than are implied in the earlier estimates, they require an increased quantity of electricity, because it may be assumed that without electrification, significantly increased capability in the Railways cannot be achieved. Simultaneously, an adjustment is made for the lower level of diesel demand in the road transport sector on account of the decreased demand for their services.

Non-Energy sector

3.32. In respect of coal, the only non-energy use contemplated is for fertilizer feedstock which has been assumed in the original forecast as 3 m. tonnes in 1978-79, 6 m. tonnes in 1983-84 and 9 m. tonnes in 1990-91.

3.33. On account of the increased price of oil products and the relative prices of fuel oil and naphtha which are anticipated to prevail, there is little likelihood of new fertilizer projects based on naphtha being taken upto 1990-91. In Case-I, it was assumed that the naphtha use for fertilizer production will remain stagnant at 2 m. tonnes from 1978-79 to 1990-91, while the naphtha demand for petro-chemicals was assumed to increase from 1.47 m. tonnes in 1978-79 to 2.27 m. tonnes in 1983-84 and 3.5 m. tonnes in 1990-91. On account of the increase in price of naphtha, there will be a slowing down of the rate of growth of petro-chemical industry in line with the anticipations for such decrease in all the countries. In Case-III, it is assumed that the level of demand would only be 60 per cent of what is forecast during the years 1978-79, 1983-84 and 1990-91. In the medium level forecast, it is taken as 80 per cent of the original levels.

3.34. Taking note of the possible levels of availability of heavy stock which may not be otherwise used, a judgement of some reasonable estimates of the likely use of fuel oil and coal for fertilizer production has been made. There are possibilities of natural gas production also. This has not been taken into account at this stage. (See Chapter VIII para 8.41). As a result of these modifications, our original estimates of coal, oil products and electricity get revised.

3.35. Summing up the revised estimates obtained for oil and the consequential adjustments to be made in the demand for coal and electricity we get the demands for specific fuels under the assumptions of Case-I, Case-II and Case-III; these are set out in the Tables 3.5, 3.6 and 3.7.

TABLE 3.5

Revised Estimates of Coal Requirement (1978-79, 1983-84 *and* 1990-91)

(In Million tonnes)

Consuming Sector	Requirements in 1978-79			1983-94			1990-91		
	Case-I	Case-II	Case-III	Case-I	Case-II	Case-III	Case-I	Case-II	Case-III
1. Steel plants and Coke ovens(a)	32	32	32	53	53	53	90	90	90
2. Thermal power generation (b)	45	48	51·2	64	68	71	118	123	127
3. Transport (Railways)	13	13	13	11	11	11	10	10	10
4. Industries	20	21·8	23	27	30·2	32·2	50	54·5	58·3
5. Brick burning) ..	8	8	8	11	11	11·00	20	20	20
6. Domestic soft coke (a)	9	10	10·6	21	22·6	24·2	30	32·5	35·6
7. Export	1	1	1	2	2	2	3	3	3
8. Colories' own consumption ..	4	4	4	6	6	6	9	9	9
I. *Total for Energy Use*	132	137·8	142·8	195	203·8	210·4	330	342·0	352·9
Non-Energy Use II. *Fertilizer Feedstock* ..	3	3·0	3·0	6	7·0	8·0	9	10·5	12·0
Total Cost Demand (I+II)	135	14 ·8	145·8	201	210·8	218·4	339	352·5	364·9

NOTES :—

(a) In terms of raw coal.

(b) Excluding middlings (5 mt in 1978-79, 12 mt in 1983-84 and 21 mt in 1990-91) which stand included under the demand steel plants. See Annex Table III(i).

TABLE 3.6

Revised Estimates of Demand for Oil Products (1972-73, 1978-79, 1983-84, 1990-91)

(In million tonnes)

Name of Product	1972-73	1978-79			1983-84			1990-91		
		Case-I	Case-II	Case-III	Case-I	Case-II	Case-III	Case-I	Case-II	Case-III
					I. *Energy Sector*					
1. L.P.G. ..	0·260	0·73	0·73	0·73	1·20	1·20	1·20	1·93	1·98	1·98
2. Motor Gas	1·592	2·10	2·00	1·91	2·55	2·43	2·32	3·36	3·14	2·93
3. Kerosene	2·449	3·40	3·20	3·12	4·40	4·10	3·81	6·09	5·55	5·01
4. A.T.F. ..	0·802	1·50	1·45	1·38	2·65	2·48	2·26	6·12	5·14	4·38
5. H.S.D.O.	5·811	10·70	9·71	8·72	15·20	13·67	12·15	27·91	23·69	19·48
6. L.D.O. ..	1·376	2·05	1·98	1·90	2·60	2·35	2·09	3·70	3·20	2·71
7. Furnace Oil	(5·629)	(5·91)	(5·11)	(4·61)	(7·95)	(6·49)	(5·62)	(11·15)	(9·09)	(7·40)
(*i*) used for power generation and industries ..		5·50	4·70	4·20	7·20	5·74	4·87	10·15	8·09	6·40
(*ii*) Coastal Bunkers ..		0·23	0·23	0·23	0·40	0·40	0·40	0·60	0·60	0·60
(*iii*) International Bunkers		0·18	0·18	0·18	0·35	0·35	0·35	0·40	0·40	0·40
8. Others ..	0·160	0·33	0·35	0·33	0·45	0·45	0·45	0·70	0·70	0·70
9. *Total* (I) ..	*18·079*	*26·72*	*24·51*	*22·70*	*37·00*	*33·17*	*29·90*	*61·01*	*2·49*	*44·59*
					II. *Other than Energy Sector*					
10. Naphtha	1·319	3·47	3·47	3·47	4·27	3·36	3·32	5·50	4·80	4·10
11. F.O. for Feedstock for fertilizer ..		1·25	1·25	1·25	2·00	1·80	1·63	3·00	2·50	2·00
12. Lubes ..	0·592	0·79	0·79	0·79	1·00	1·00	1·00	1·30	1·30	1·30
13. Bitumen	1·140	1·58	1·58	1·58	2·55	2·32	2·11	5·00	3·98	3·18
14. Others ..	0·510	0·60	0·60	0·60	0·93	0·93	0·93	1·67	1·67	1·67
15. *Total* ..	*35· 61*	*7·69*	*7·69*	*7·69*	*10·75*	*9·41*	*8·99*	*16·47*	*14·25*	*12·25*
16. GRAND TOTAL (I)+(II)	21·640	34·41	32·20	30·39	47·75	42·58	38·89	77·48	66·74	56·84

TABLE 3.7

Revised Estimates of Demand for Electricity 1978-79, 1983-84 *and* 1990-91)

END USE METHOD

(billion KWh)

	Requirement in								
	1978-79			1983-84			1990-91		
	CASE			Case			Case		
	I	II	III	I	II	III	I	II	III
1. Major industrial consumption	47·89	47·89	47·89	80·2	80·2	80·2	145·0	145·0	145·0
2. Other industrial consumption	20·59	20ff59	20·59	35·5	35·5	35·5	65·0	65·0	65·0
3. Total industrial consumption	68·48	68·48	68·48	115·7	115·7	115·7	210·0	210·0	210·0
4. Domestic consumption	8·68	11·53	14·38	15·6	18·4	21·2	25·9	27·1	28·3
5. Commercial consumption	5·58	5·58	5·58	9·8	9·8	9·8	21·6	21·6	21·6
6. Public lighting ..	1·10	1·10	1·10	2·0	2·0	2·0	4·4	4·4	4·4
7. Traction (Railways)..	3·25	3·35	3·44	5·7	6·1	6·5	12·6	13·9	15·2
8. Irrigation & dewatering	10·00	10·30	10·90	14·2	15·7	17·2	40·5	43·4	46·3
9. Total consumption ..	97·09	100·34	103·88	163·0	167·7	172·4	315·0	320·4	325·8
10. Losses and Auxiliary consumption ..	22·77	23·66	24·12	35·8	37·3	38·6	70·0	71·6	72·2
11. Total generation required	119·86	124·00	128·00	198·8	205·0	211·0	385·0	392·0	398·0

Forecast of demand for Non-commercial Energy

3.36. The domestic sector consumes energy derived from commercial fuels like coal, coke, kerosene, LPG and electricity and non-commercial fuels like firewood, vegetable waste, cowdung, etc. There is no way of direct measurement of the extent of use of non-commercial fuels. The methods of estimation of non-commercial fuels are discussed in Chapter X. Briefly, from the field studies, the average per capita consumption in the domestic sector in urban and rural households is first estimated and from this the total requirements of energy for the domestic sector is computed. The availability of commercial fuels to domestic sector at different points of time in future are determined and the residual represents the likely level of consumption of non-commercial fuels. In the estimates of future demand of coal, oil and electricity, the possible levels of non-commercial fuels that would be used in the domestic sector have been calculated. Based on these data, the implied levels of use of non-commercial fuels have been estimated and the results are set out in the Table 3.8. (See Chapter X, para 10.7 for details).

TABLE 3.8

Estimates of Demand for Non Commercial Fuels (1978-79, 1983-84 *and* 1990-91)

(In million tonnes/in meter)

	1978-79		1983-84		1990-91	
Firewood and charcoal	132	125	131	124	122	116
Dungcake (dry) ..	65	26	65	26	53	21
Vegetable waste ..	46	44	46	44	46	44
Total ..		195		194		181

3.37. Fuel requirements, both commercial and non-commercial, for energy use only as estimated by the Committee may be summarised as follows:

TABLE 3.9

Estimates of Demand of Fuels (For Energy Use) in 1978-79, 1983-84 and 1990-91*

(In mtcr)

Fuel	Year 1978-79	1983-84	1990-91
1. Coal**	85	124	198
2. Oil products*** ..	173	237	380
3. Electricity ..	*100*	*167*	*320*
4. Total commercial energy	358	528	898
5' Non-commercial fuel	195	194	181
6. Total energy ..	553	722	1079

*Based on Case-II estimates.

**Excludes coal for power generation

***Excludes fuel oil used for power generation :

1978-79	.. ..	1·5 m. tonne
1983-84	.. ..	2 ,,
1990-91	.. ..	4·6 ,,

3.38. A comparison of the estimates obtained by the end-use method with the estimates obtained by regression analysis shows that these estimates are close to each other in respect of total commercial energy (see para 3.7). But in respect of specific fuels regression analysis gives slightly higher estimate for coal and oil. This is to be expected as the shifts in technology over the years have been slowly in favour of lesser utilization of coal directly as a fuel and substitution of electricity. Oil consumption increase has been kept in check in the end-use analyses by substituting electricity in transport and agricultural sectors. This has led to the end-use estimate of electricity being larger than the estimates obtained by regression analysis.

3.39. The rates of growth of demand for different commercials fuels during the future Plan periods implied in our forecasts are summarised below in Table 3.10. As coal production has to be increased to a level adequate to supply coal demand including coal for power generation demand including coal for power generation has been taken into consideration. Similarly fuel demand for non-energy uses has also been included.

TABLE 3.10

Rates of Growth of Demand for Different Fuels: (1978-79, 1983-84, 1990-91)*

(in % per year)

Period	Coal	Oil	Electricity	Total** commercial energy
1970-71 to 1978-79 ..	9·4	8·6	9·5	7·8
1978-79 to 1983-84 ..	8·4	5·8	10·8	8·1
1983-84 to 1990-91 ..	7·6	6·6	9·7	7·9

*Calculated in terms of original units

**Calculated in terms of mtcr.

3.40. The rates of growth of coal demand may come down slowly in each Plan period from about 9.4 per cent in the period 1978-79 to 8.4 per cent in the Sixth Plan period and 7.6 per cent then on. In the case of oil, it will be seen that oil consumption goes down sharply from 8.6 per cent in the period upto 1978-79 to 5.8 per cent in the Sixth Plan period which then increases to 6.6 per cent in the Seventh Plan period and upto 1990-91. The sharp decrease during the Sixth Plan period in oil consumption arises on account of our assumptions of shifts from oil to other fuel forms during the Sixth Plan period. Though we have advocated the measures to be taken in the Sixth Plan period, the benefits of substitution of oil products by electricity and, in some measure, by coal, will come into operation only during the Sixth Plan period. This will result in raising the growth rate of electricity consumption during the Sixth Plan period to 10.8 per cent. It may be relevant to note here that this also reflects the strategy implied in the long-term perspective of growth of the Indian economy given in the Draft Fifth Plan.

3.41. The magnitude of the production effort called for power and coal sectors (where deficits in domestic production cannot be easily met by imports) to achieve the pattern of fuel usage suggested in this Report can be seen from the Table 3.11 which gives the average annual increase in production in each Plan period.

TABLE 3.11

Average Annual Increase in Demand For Fuels

Period	Coal* in million tonnes	Oil in million tonne of reproducts	Electricity in b. kWh
1. 1970-71 to 1978-79	9·1	1·8	6·4
2. 1978-79 to 1983-84	14·0	2·1	13 4
3. 1983-84 to 1990-91	20·3	3·4	21·8

*Excluding Lignite.

3.42. It is relevant to note that the increases in the per year addition to production of coal, oil products and electricity will slowly increase over time inspite of the reduction in the rates of growth in oil noticed in the Sixth Plan period. The production per year will of course increase gradually each year, if adequate advance action is taken in the energy sector. But Table 3.11 has been given to highlight the magnitude of the tasks which will be cast on coal, oil and electricity industries in future.

3.43. The estimates given in this Report are in the nature of conditional statements and they are derived from the rate of growth of the economy, the structure of the economy and structure of the industries as foreseen now. The estimates for 1978-79 do not reflect any large variations in the demand for oil products as a measure of economy in the use of oil and some substitution of oil products for power generation and for heat raising in industries by coal has already been assumed in the first estimates. Given the limitations on increasing coal and electricity, the Committee did not think it realistic to forecast any severe reduction in the use of oil; but it should be noted that the Committee has not examined the possibilities of curbing elitist consumption of selected oil products by administrative action. But the alternative patterns of usage suggested in this Report will mean a saving of about 5 m. tonnes in 1983-84 and 11 m. tonnes in 1990-91. If all the measures suggested in the Report are taken, the pattern of usage of oil products will come to be closer to Case-III where, by 1990-91, about 21 m. tonnes of oil products could be saved. It is worth reiterating here that excepting for some quantities of energy which can be reduced by giving up a measure of comfort, reduction in the use of a particular fuel will mean an increase in quantity of another fuel. It is therefore necessary to note that the patterns of usage of Case-I, Case-II and Case-III should be treated as different patterns of fuel usage.

CHAPTER IV

FUEL RESOURCES OF INDIA

Non-commercial fuels

4.1. The major fuel resources available in India are coal, oil, natural gas, hydro-electric potential and nuclear fissile material. In addition, very large quantities of non-commercial fuels like firewood, cowdung and vegetable waste are utilised in the country. Non-conventional resources, in the exploitation of which very little progress has been made so far, include geo-thermal energy, solar energy, tidal power and wind power. A survey of the availability position of each of these resources is necessary for analysing the supply possibilities of energy from indigenous sources.

4.2. Coal is the largest naturally occurring source of commercial energy in India. The resources position is assessed by the Geological Survey of India through regional mapping, exploratory drilling and detailed drilling. In some cases detailed drilling has also been done by the National Coal Development Corporation and some State Governments like Maharashtra. Methods of computation of reserves have varied from institution to institution. A coordinated estimate was made* recently of the total quantity of coal available in coal seems of more than 1.2 meters thickness down to a depth of 600 meters. The detailed estimates of reserves for the different coalfields are given in Annex-IV(1). A summary of the total gross reserves of the different varieties of coal is given in Table 4.1.

TABLE 4.1

Summary of Reserves of Coal Available in India

	Total Gross Reserve	Proved Reserves	Indicated Reserves	Inferred Reserves
1. *Coking Coal*				
Prime coking coal ..	5,650	3,650	1,540	460
Medium coking coal ..	9,431	3,850	4,309	1,272
Semi to weakly coking coal	5,073	1,559	2,600	914
Total coking coal ..	*20,154*	*9,059*	*8,449*	*2,646*
2. *Non-coking coal*				
Non-coking coal ..	59,968	12,306	22,310	26,180
Tertiary coal ..	288			
3. *Lignite*				
Lignite	2,025	1,795	202	28
Grand Total ..	82,975	23,160	30,961	28,854

*Report of the Task Force on Coal & Lignite, April, 72.

Metallurgical coal

4.3. Of the gross metallurgical coal reserves totalling about 20,000 mt, about 9000 mt are proved. These are concentrated in the Jharia, Bokaro, Ramgarh, Giridih and Karanpura coalfields in the State of Bihar. Some quantity of coking coal mostly of the medium and semi to weakly varieties are found in the Raniganj coalfield in West Bengal and the Pench Kanhan coalfields in Madhya Pradesh. The coking coal reserves are classified as prime coking which can be used for the production of metallurgical coke and medium, semi coking and weakly coking which can be used for preparing metallurgical coke only in combination with prime coking coal. The prime coking coal is thus an absolute necessity for the metallurgical industry of the country. The resources of this variety of coking coal which is found almost exclusively in the Jharia coalfield are extremely limited, the total proved reserves being about 3600 mt. and the indicated and inferred reserves being about 2,000 mt. Considering the losses in mining and washing which are unavoidable and the fact that the coal mined in the future is likely to be high ash variety, the net available reserves of prime coking coal are estimated at only 1600 mt. This together with the estimated availability of medium and blendable coal will be able to sustain the growing requirement of the steel industry for a period of about 40 years only. Conservation of the scarce reserves of coking coal as well as measures for minimising the coke consumption in blast furnaces may lead to the extenison of life of the reserves. (See Chapter VII). Another feature of the coking coal available which has to be noted in the context of the planning of steel production is that nearly 98 per cent of the coking coal reserves are located in the Bengal-Bihar coalfields —mostly in Bihar. Another fact is that much of the coking coal, particularly the medium and blendable coal, would have to be beneficiated before it can be used for the manufacture of metallurgical coke, unless technology is developed, which would enable the use of high ash coke in the blast furnaces. There are also prospects of beneficiating non-coking coal to "formed coke" for use in the steel industry. (See Chapter VII).

Non-Coking Coal

4.4. With regard to the availability of non-coking coal and lignite, the position is somewhat better. The gross reserves are estimated at about 63,000 mt of which about 14,000 mt including about 1800 mt of lignite, represent proved reserves. The balance of about 49,000 mt being indicated and inferred reserves, the percentage of

non-coking coal available for exploitation would be significantly less. The requirements of non-coking coal are anticipated to go up steeply with the large increase in thermal power generation. In view of the uncertainty in the trend of demand as well as the fact that much of the reserves are yet to be proved, it is difficult to predict with any reasonable degree of accuracy the period for which the non-coking coal reserves are likely to last. On a very rough calculation, it may be stated that the reserves of non-coking coal that have been categorised so far would last for about 100 to 150 years. However, exploration for coal seams is a continuing process and it is possible that new deposits might be discovered and also that the proving of reserves might indicate the availability of larger quantities.

4.5. About 60 per cent of the non-coking coal reserves occur in the Bengal-Bihar coalfields. Other major coalfields are Korba, Singrauli, Korea, Rewa, Hasdeo-Anand and Mand-Raigarh in Madhya Pradesh, Talcher and Ib river in Orissa, Chandawardha and Kamptee in Maharashtra and Singareni in Andhra Pradesh. The North-Eastern region comprising the States of Assam, Meghalaya, Nagaland, Arunachal also contain low ash coal most of which is still in the indicated and inferred category.

4.6. As in the case of coking coal, the vast majority of the non-coking coals contain high percentage of ash. The good quality coals, that is coal with ash plus moisture together not exceeding 19 per cent, comprise about 460 mt. of proved reserves only. The reserves of superior grades of coal are thus extremely limited and it would be necessary for the consumers to adapt themselves to the high ash varieties which are available in abundance.

4.7. Table 4.2 depicts the resources of coal available in each region and State:—

TABLE 4.2

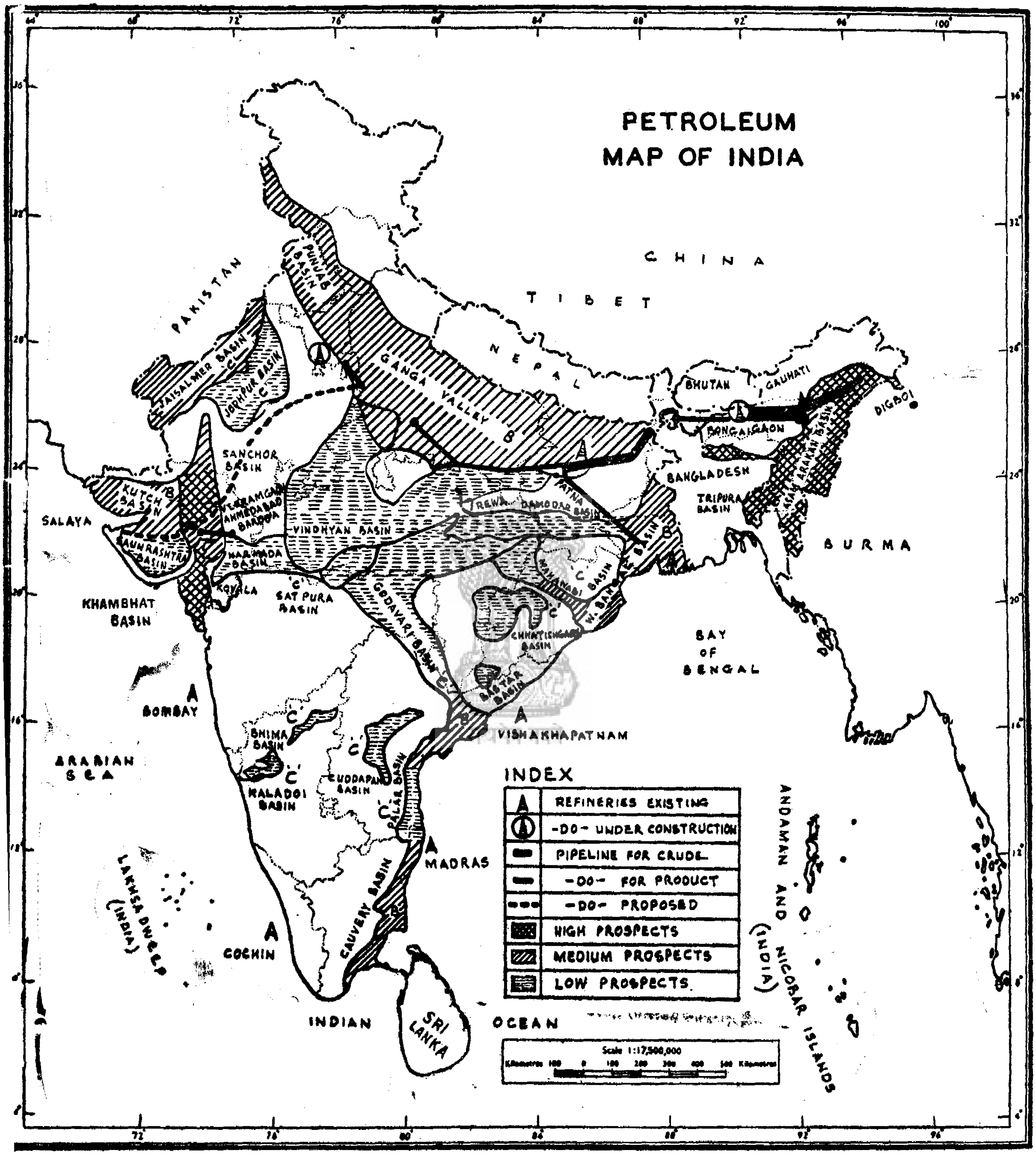
Categorywise/Regionwise Availability of Coal Reserves

(in mt)

Region	Proved	Indicated	Inferred	Total
I. *Non coking coal* :				
N. E. Region ..	139	291	398	828
E. REGION				
W. Bengal	3,071	5,22	8,848	17,139
Bihar	2,603	8,647	6,612	17,862
Orissa	895	2,411	1,810	5,186
CENTRAL REGION				
Madhya Pradesh ..	4,142	3,864	7,168	15,174
WESTERN REGION				
Maharashtra.. ..	478	800	1,344	2,622
SOUTHERN REGION				
Andhra Pradesh ..	978	1,077	..	2,055
Total	12,306	22,310	26,180	60,796
II. *Coking coal* —				
E. REGION				
W. Bengal	967	775	738	2,480
Bihar	7,987	7,470	1,908	17,365
CENTRAL REGION				
Madhya Pradesh/U.P.	105	204	..	309
Total	9,059	8,449	2,464	20,154
III. *Lignite* — W. REGION				
Gujarat	78	..	..	78
S. REGION				
Tamil Nadu ..	1,717	202	..	1,919
N. REGION				
Rajasthan	..	..	20	20
Kashmir	..	..	8	8
Total	1,795	202	28	2,025
Grand Total ..	23,160	30,961	28,854	82,975

SOURCE:— Constructed from the Report of the Task Force on Coal and Lignite—April, 1972.

4.8. A major portion of non-coking coal resources is located in the Eastern region which also contains almost all the coking coal reserves. The unexploited reserves of non-coking coal are also maximum in this region. This is, however, situated rather unfavourably from the point of view of transport because of sizeable portion of the increase in demand for coal, particularly for power generation, is arising in the Western and Northern regions. The nearest coalfield to the Northern region is Singrauli which has considerable potentialities as its exploitation started only very recently. With extensive exploitation it is possible (since the total gross reserves amount to more than 9,000 million tonnes) for this field to meet a substantial portion of the needs for power generation in Northern India for a period of over a hundred years. The coal demand in the Western region should nomally be met from the resources available in the coalfields of Maharashtra and Madyha Pradesh. By considering the likely demand over time for coal in the Western region and the coal resources in Maharashtra and M.P. it appears necessary that the supplies from these coalfields will need to be supplemented with coal from the Eastern region. The Southern region had long been dependent on hydro-electric power and hence thermal power generation had occupied an insignificant place in the past. But in the last decade the need for a rational balance between thermal and hydel generation has been recognised and the demand for coal has been rapidly rising. The two deposits available in the Southern region are those in Singareni amounting to over 2000 million tonnes and the lignite deposits at Neyveli also estimated at



ased upon Survey of India map with the permission of the Surveyor General of India

he territorial waters of India extend into the sea to a distance of twelve nautical iles measured from the appropriate base line.

e boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas eorganisation) Act, 1971, but has yet to be verified.

about 2000 million tonnes. Besides serving as a fuel for power generation, lignite is also being used as a raw material for production of fertilizers and smokeless domestic fuel. Due to the relatively difficult mining conditions obtaining in Singareni and Neyveli the development of mines in these fields is likely to be slow. The Southern region would, therefore, have to be supplemented with coal supplies from the Eastern region i.e., from the coalfields in Orissa and Bengal-Bihar. *The locational aspect of the coal deposits in the country underlines the need for developing an efficient and adeqaute transport system which would ensure the flow of available fuel resources from the points of availability to points of requirements.*

4.9. In the oil prospect map of India, 27 basins have been delineated by the petroleum geologists on land and off shore covering a total sedimentary area of about 1.41 million sq. km on land and about 0.26 million sq. km lying with the 100 metre isobath of shelf-zone in the Indian offshore. The geological basins of possible interest from the point of view of oil exploration are categorised below according to their prospective value.

TABLE 4.3

Categorywise Sedimentary Areas in India

Category	Basins Sedimentary (including offshore parts)	Total Sedimentary Area including offshore (thousand sq km)	Remarks
A	Cambay, Large part of Assam—Arakan ..	300	High propspects. These are areas with thick sections of marine sediments of relatively younger age and are known to contain commercial oil/gas
B_1	Small part of Assam-Arakan, Gauvery, West-Bengal, Jaisalmer, Tripura, Cachar and Andaman Nicobar	250	Medium prospects. These are areas with thick sections of marine sediments of relatively younger age, but so far have no known commercial oil/gas fields
B_2	Ganga Valley, Punjab, Godavari-Krishna, Damodar Graben, Mahanadi Graben, Narmada, Kutch, Saurashtra, Kerala, Laccadive and Palar	670	Fair prospects. These are areas with thick sections of sedimentary rocks of older ages, either wholly or mostly non-marine or have some other unfavourable geological features
C	Cuddapah, Kaladgi Bhima, Chatisgarh, Bastar, Vindhyan, Jodh Pur, South Rewa, Satpura, Sancher-Barmer	450	Low prospects. These are areas with sedimentary rocks of extremely old age
	Total Sedimentary Area (including offshore)	1,670	

SOURCE:—Oil and Natural Gas Commission.

4.10. A map showing the location of these basins is attached. Of the 27 sedimentary basins on land 12 basins have very ancient sediments and have therefore very low priority. Exploratory drilling so far has been conducted, mainly on land, in 7 of the more promising basins. 90 per cent of the total volume of exploratory meterage drilled todate is concentrated in two basins of the greatest interest viz., the Cambay (Gujarat) and Assam basins which between them contain all the known oil fields of India today. The well studied oil bearing area constitutes about 4 per cent of the total area of the Indian sedimentary basins which could be the habitat for oil.

4.11. The continued discovery of new oil fields, though comparatively small in size on land in Gujarat, and of a medium sized field in Assam area indicates the possibility of discovering more oil in these areas. A total of 19 oil fields have so far been discovered in the Cambay basin of Gujarat since 1958. In addition, six oil fields have so far been discovered by Oil and Natural Gas Commission in the Southern part of the Assam shelf. Three fields have been discovered and two are being worked by Oil India Limited and one small field is being worked by the Assam Oil Company in this area. Despite the large volume of exploratory worked the upper Assam shelf is not as well studied as the land part of the Cambay basin of Gujarat. The hydrocarbon prospects of only 16 structures have been so far evaluated by drilling in Assam—Arakan area out of 20 structures prepared by surveys, leading to discovery of four oil fields. Thus, there is a good chance of discovering more oil fields in the Assam region in future years. On the other hand, about 100 structures have been so far discovered in the Cambay basin of Gujarat, including 12 possible oil bearing structures located in the shelf zone off the west coast. Out of these, the hydrocarbon prospects of 72 structures on land have been evaluated by drilling and chances of big discoveries on land in future seem remote. However, out of the 12 structures discovered by geophysical surveys in the shelf zone mainly of Arabian Sea, only three at Aliabet, Tarapore and

Bombay High have been partly explored by drilling till recently. The first well drilling at Bombay High structure has penetrated many promising oil and gas bearing layers. But the potential of the structure has to be studied with reference to a few more holes to be drilled and through trial production over a period of time. It is as yet too premature to make any forecast of the likely production from this structure. The Committee, therefore, did not consider it desirable to revise the assumptions regarding production of crude from Indian oilfields made prior to the findings at Bombay High.

4.12. The proved reserves of crude oil and natural gas are shown in Table 4.4.

TABLE 4.4

Reserves of Crude and Natural Gas

Area			Crude Oil (In million tonnes)	Natural Gas (In million Cubic Metres)
Gujarat	..	..	56·38	19·66
Assam	..	..	71·46	42·82
Total		..	127·84	62·48

SOURCE:— Indian Petroleum and Chemicals Statistics, 1972.

Recent explorations within the country (e.g., in Tripura and Bombay High areas) and in concessions operated abroad (e.g., certain Persian Gulf areas in the middle east) hold promise of discovery of gas in substantial quantities which may increase several fold the availability of natural gas to India.

4.13. In the Fifth Five Year Plan period, the Oil and Natural Gas Commission has drawn up plans to prove recoverable oil reserves to the extent of 64 mt inclusive of 5 mt. to be discovered and proved in the offshore areas. This is estimated to enable ONGC to achieve and sustain a production of 8 mt. of oil per year in 1978-79. The forecast of proving of reserves and production is contingent on the level of exploration and development work done by ONGC being atleast as intensive as indicated in the Fifth Five Year Plan programme. The Oil India Ltd. which is exploiting the oil fields in Assam has an exploration programme which would enable them to reach and maintain a production of about 3 mt. of crude per year by 1978-79. The All India production of crude will, therefore, be about 12 mt by 1978-79 including offshore production. There is likely to be variations between what is expected and what is achieved.

4.14. For the period beyond 1978-79 detailed studies have not been made. Preliminary studies, however, indicate that if adequate funds are made available for exploration activities, recoverable resources of about 130 mt. could be established in 5 years and ONGC's oil production alone can be about 13 mt by 1983-84. It is reasonable, therefore, to forecast a production rate of about 15 mt of oil per year by 1983-84. These projections of oil production and reserves likely to be added are essentially prognastic estimates of statistical nature based on experience and skill gained so far expresed in terms of oil reserves discovered per metre drilled.

4.15. In order that these forecasts are realised in future the following steps may have to be taken:

(i) Expedite the exploratory drilling in the Bombay High region.

(ii) Undertake a large volume of exploration drilling operations in the Tripura and Cachar areas and in the South-Eestern border of the Upper Brahmaputra Valley.

(iii) Re-survey some already explored portion of the Cambay basin and the Upper Brahmaputra valley region of the Assam-Arakan Basin using sophisticated geophysical techniques, and intensive exploration drilling operations in such portions, to locate additional traps in particular stratigraphics which might have been missed in the course of the exploration work conducted earlier.

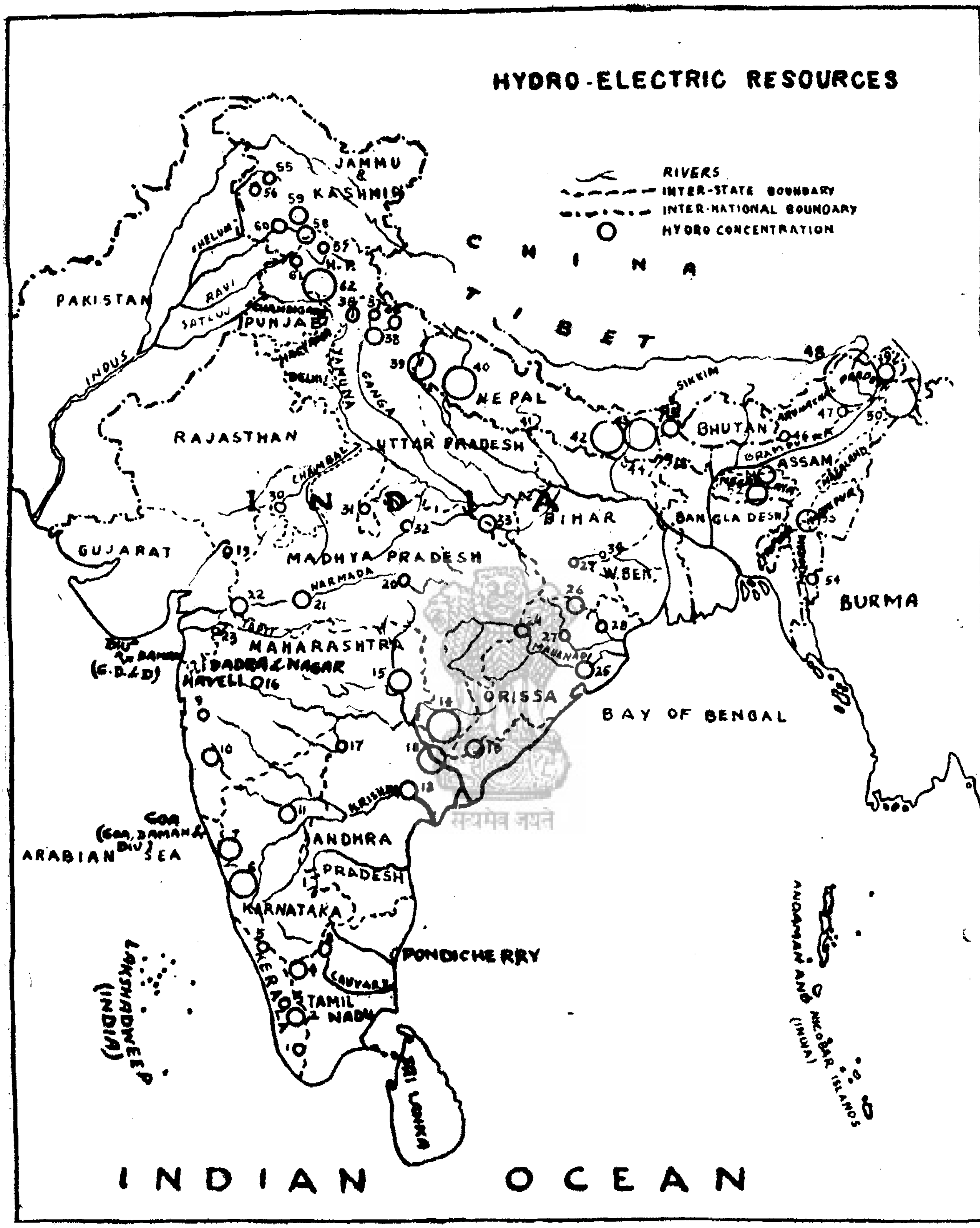
(iv) Extend the exploration operations to the portions of the Cambay basin and the Upper Brahmaputra Valley region of the Assam-Arakan Basin which had not been explored so far.

(v) Conduct extensive seismic surveys in all the areas and follow up the results by drilling of exploration wells. Priority to be assigned to the continental shelf in the Arabian Sea adjoining the area already covered, the continental shelf area south of Sunderbans and the continental shelf area of the Andaman Islands.

(vi) Test by deep drilling already known structures in the Shiwalak foot hill belt of Jammu and Kashmir, Punjab and Himachal Pradesh.

(vii) Intensify the exploration work, including seismic surveys and drilling operations, in the Ganga valley in West Bengal, Saurashtra and Jaisalmer area.

(viii) Intensify the exploration work, including commencement of exploration drilling, in the land area of Andaman & Nicobar Islands.



1. BASED UPON SURVEY OF INDIA MAP WITH THE PERMISSION OF THE SURVEYOR GENERAL OF INDIA.
2. THE TERRITORIAL WATERS OF INDIA EXTEND INTO THE SEA TO A DISTANCE OF TWELVE NAUTICAL MILES MEASURED FROM THE APPROPRIATE BASE LINE.
3. THE BOUNDARY OF MEGHALAYA SHOWN ON THIS MAP IS AS INTERPRETED FROM THE NORTH-EASTERN AREAS (REORGANISATION) ACT, 1971, BUT HAS YET TO BE VERIFIED.

The findings in regard to the potential of Bombay High, if composed soon, will enable the Government to draw up the priorities for action in oil exploration on a firmer basis.

4.16. In addition to oil available within the countriy, India also owns a small share in the oilfields in the Persian Gulf and the oil from this source on normal assumption can be considered as an available resource of India. Indian owns a part of the Rustam and Rakash oil fields in the Persian Gulf along with AGIP of Italy and Philips Oil Co. of U.S.A. These oil fields together produced about 4 mt of crude in 1972 of which India's share is 1/6th. The production in these two fields is expected to decline gradually and by 1978 it would be a little less than 2 mt and by 1985 it would be around 0.75 mt. But there are some possibilities of increase in production through secondary recovery methods and by exploring new areas in the lease-hold available in these fields. Recent exploration indicates possibility of large resins of gas being formed in the lease area.

Hydro-electric resources

4.17. India is fortunate in having several mountain ranges and large river systems which would suggest vast hydel power resources. These have been assessed on the basis of the results of surveys conducted by the Central Water and Power Commission between 1953—58*.

The Central Water and Power Commission study made the evaluation with reference to 260 specific schemes on the various river systems. The river systems were classified into the following groups:

(i) The West flowing rivers of Southern India covering the Western Ghats and the Coastal strip from Goa to Kanya Kumari.

(ii) The east flowing rivers of Southern India.

(iii) The rivers of Central India which flow to the east and to the west.

(iv) The Ganga basin including its Himalayan and peninsular tributaries.

(v) The Brahamaputra basin and neighbouring drainage areas in Assam, Meghalaya, etc.

(vi) The Indus basin covering the tributaries of the Indus in India.

The economically usable hydro electric potential estimated for each of these river systems and its Statewise distribution is given in Table 4.5.

TABLE 4.5

Statewise Distribution of Power Potential

State	M. W. at 60% L F
1. Andhra Pradesh	2,476·5
2. Assam (including Meghalaya, Nagaland and Mizoram) ..	11,599·4
3. Bihar	609·7
4. Gujarat	677·0
5. Jammu & Kashmir	3,590·5
6. Kerala	1,539·5
7. Madhya Pradesh	4,582·3
8. Madras	708·2
9. Mahasrashtra	1,909·6
10. Mysore	3,372·8
11. Orissa	2,062·0
12. Punjab & Haryana	1,360·5
13. Rajasthan	149·0
14. Uttar Pradesh	3,764·0
15. West Bengal	22·0
16. Himachal Pradesh	1,867·5
17. Manipur	865·0
Total	41,155·5

SOURCE:—Central Water and Power Commission.

The distribution of energy potentials of all possible hydel schemes, region-wise, is set out in Table 4.6:

TABLE 4.6

Hydel Energy Potentials of Various Regions of India

(Hydel potential)

Regions	Billion kWh	Percentage of Total
Eastern	14·2	6·5
Northern	36·6	16·9
Central	43·9	20·3
Western	13·6	6·3
Southern	42·6	19·7
Assam	65·5	30·3
Total	216·4	100·0

4.18. The above power potential has been worked out at 60 per cent load factor but eventually the potential may have to be worked out on a lower load factor, as most of the hydroelectric stations will be used as peaking stations. Of the total power potential, about 10.3 million

*This has been given in detail in the Report of the Energy Survey of India Committee 1965—Annexure 3 prepared by the CW&PC.

kW i.e. 25 per cent represents potential of simple "run-of-the river" type projects in the Himalayan ranges and the rest "storage projects" (Energy potential will be 54 billion kWh). "High head" type projects utilising drops over 300 metres account for about 13.63 million kW with energy potential of 71 billion kWh. "Medium head" type projects i.e., drops from 30 metres to 300 metres account for 23.86 million kW with energy potential of 126 billion kWh and "Low head" projects ranging from 8 to 30 metres mainly "lift" dams below the major reservoirs have a total of about 3.66 million kW with energy potential of 19 billion kWh. These hydro-electric resources are widely distributed all over the country, there being few regions of the country which are situated more than 500 km from major concentrations of hydro power such as the Himalayan sources, the Shillong plateau, the Eastern Ghats and the Western Ghats which utilise the natural advantages of the mountains. Schemes in the middle and lower reaches of rivers like the Narmada, the Chambal, the Sone, the Mahanadi and the Godavari derive their potentials from the topographic characteristics permitting the construction of large reservoirs.

4.19. Schemes which are currently in operation or under construction or whose investigations have been completed cover potentials of about 6 million kW, 1.2 million kW and 4.4 million kW respectively. The exploitation of hydro electric potential has been minimum in the North-Eastern region which actually contains the largest potential of all the regions. Table 4.7 indicates the estimated hydro electric potential available and the quantity developed and under development.

TABLE 4.7

Regionwise Distribution of Hydro Electric Resources and Their Utilization (as in 1970)

Region	Total resources at 60% LF (MW)	Resources developed and under development (MW)	Percentage of utilisation (i. e. of col. 3 to col 2.)
Southern	8,097	3,221	38·8
Western	7,189	942	13·1
Northern	10,731	2,451	22·8
Eastern	2,694	475	21·3
North-Eastern	12,464	38	0·3
Total	41,155	7,225	17·5

SOURCE:—Report of the Power Economy Committee 1971.

Nearly one-third of the remaining potential of 29.5 million kW which has yet to be established by field investigations, represents potential of "run-of-the-river" projects. This does not require extensive investigations as the dependable power drafts have been estimated on the basis of gauged data available for the Himalayan rivers for fairly long periods.

4.20. In the Himalayan region there is considered to be a scope for possible upward revision of the estimated hydro electric potential. The 'Seasonal' energy potential that would be available largely at the sites of multipurpose projects in Peninsular India has not been included in the above estimates. The Power Economy Committee expressed the view that "on the basis of the latest information regarding hydel energy resources and their economics of development, it would be possible to instal about 80 to 100 million kW of hydel capacity on our river systems during the next two to three decades.........". In the absence of details this committee has taken note of the hydel potential as indicated by CW & PC. *The Committee would recommend that a more systematic delineation of our hydro-electric potential should be taken up as soon as possible.*

4.21. The Government have recently taken steps to declare water as a national asset. This measure has come none too soon. If India is to make full use of its vast hydro electric resources a national approach would be necessary and the hydro electric power generation being the cheapest method of generating energy, full atteniton should be given to the development of these resources in as economically and speedy a manner as possible. *The first step required is the detailed investigation of the untapped resources in different regions of the country.* Possibly one factor which might have deterred the exploitation of hydro power in the Himalayan and Assam regions was the lack of demand for power locally as well as practical difficulties in tapping the resources. With the concept of a national power grid coming into existence, electric power should be developed wherever it is possible to do so economically and be fed into the national grid for transmission to the load centres.

Nuclear energy

4.22. Uranium is the only primary fuel that can be directly used in nuclear reactors. Extensive prospecting and exploration efforts of the Department of Atomic Energy during the last two decades have led to the discovery of a number of occurrences of uranium in India. The most important region in India for uranium ore is the Singhbhum region in Bihar. The Jaduguda mines and the Narwapahar mines situated in this area are the most important uranium mines so far. There are also other possible uranium deposits in the Singhbhum belt. The copper deposits of this region also contain small amounts of uranium. The tailings from the copper mines near Jaduguda may yield uranium at economic prices.

4.23. The reasonably well assured uranium resources in India are about 22,000 Te U_3O_8 with an additional inferred reserves of 24,000 Te U_3O_8. Uranium mined in India is slightly more expensive than in many other countries, since the uranium concentration in the ore is relatively low in India. However, this is not of any grave consequence as the fuel cost forms only a small component of the total unit energy cost from a nuclear power station.

4.24. The Government have already initiated a nuclear power programme based on natural uranium fuelled and heavy water moderated and cooled reactors. Except for the first nuclear power station of 400 MW at Tarapur which requires enriched uranium as fuel, all use natural uranium as fuel. At present 600 MW nuclear generating capacity is in operation in Maharashtra/Gujarat and Rajasthan, another 640 MW is under construction in Rajasthan and Tamil Nadu and the construction of a 440 MW power station in Uttar Pradesh is about to start. As these first generation power stations would need a loading of about 4 kg of uranium per kW installed for 30 years of operation, the presently proved and inferred uranium resources in India would support only about 10,000 MW of installed nuclear capacity based on the current type of nuclear reactors. Moreover, out of the 120 kg uranium that will be loaded every year per MW of installed nuclear capacity about 2 kg only will be actually consumed in the reactor and 0.5 kg of plutonium will be produced. The rest of the uranium cannot be used as such in the present type of nuclear reactors. Nevertheless, the plutonium produced in these reactors and the discharged (i.e., used) uranium, could be used in fast breeder reactors which are being developed in India and are expected to be in commercial operation before the end of the next decade. Once these fast breeder reactors come on line by 1985--90, they will produce more plutonium than they would burn, and then the uranium resources available in India would be able to support about 600,000 to 10,00,000 MW of installed capacity for a life time of 30 years. Thus the potentially available energy from the presently known uranium deposits in India would amount to about 120×10^3 to 200×10^3 billion kWh of electricity.

4.25. Thorium reserves in India are the largest in the world and are estimated at about 4,50,000 tonnes. Besides, the fast breeder reactors would be able to produce fissile Uranium—233 from thorium that is abundantly available in India. After the fast breeder reactors passed on thorium are introduced, there will be virtually no limit to the capability to generate electricity from the resources point of view, as a total of about 2.4×10^6 billion kWh of energy will be potentially available from the known thorium resources.

*Non-conventional sources of energy

4.26. This term is used to cover sources of energy such as Solar energy, Geo-thermal energy, Tidal power, Wind power and Chemical sources. As would be seen from the assessment made in the following paras, these sources would be of negligible value in the next few years, as a source of supply for the country's energy needs, though R & D in identified areas of application holds considerable promise.

Solar energy

4.27. The annual average intensity of solar radiation in India is 600 calories per square centimetre per day. As the radiation is intermittent and variable in its availability, the typical clear sky intensity has been estimated at 1 kW per square metre of which one-half is from visible light, most of the balance near infra-red-radiation and a very small amount of ultra violet radiation. Tapping of solar energy can be effected either through flat plate collectors or focussing collectors. All practical solar energy systems now in use are of the flat plate variety. Materials, costs and operating problems are stated to be coming in the way of focussing systems being used widely. The popular applications of solar energy are solar evaporation in the salt industry, water heating, desalination of water through distillation, solar drying, solar cells. Other fields where solar energy can be applied are refrigeration, air conditioning, water pumping, cooking, conversion through plants into liquid and solid transportable fuels. In India, research has been conducted on the use of solar energy in several *institutions like:*

(i) Central Building Research Institute, Roorkee, which has designed a flat plate solar energy collector and solar water heaters;

(ii) Central Salt and Marine Chemicals Research Institute, Bhavnagar, which is conducting investigation on solar radiation, solar distillaiton, solar ponds etc.;

(iii) Defence Laboratory, Jodhpur, where an equipment for treating living space at high altitudes, solar stills, solar water heaters and hot boxes have been developed;

(iv) Solid State Physics Laboratory (SSPL), where the work on solar cells such as Silicon, Gallium Cells and Telleurium Cells is underway;

(v) Auroville School of Environmental Studies at Pondicherry, where a project of "Natural Energy based Eco-house"

*This section has been prepared with the co-operation of the Secretariat of the National Committee or Science and Technology.

is proposed. The solar energy would be utilised for heating water and day time cooking by low pressure steam, the development of solar pumps is also proposed;

(vi) At Central Arid Zone Research Institute some work is being carried out on solar heating;

(vii) Academic institutions like IIT, Madras, Jadavpur University, Regional Engineering College, Allahabad etc. are studying and experimenting with various forms of utilisation like heating/cooling etc.

The most important requisite for large scale use of solar energy is the development of capacity to store it when available and use later. Considerable research will have to be done to develop an economic and reliable 'Cell' which can store solar energy.

One possible method of directly utilising solar energy is to produce fuel through photo-synthesis. In this method, certain selected fuel species are grown in areas which have low soil fertility and the wood extracted from the plantation is used mainly as fuel or converted to liquid fuel (Methanol). With a photo-synthesis conversion efficiency of 0.5 per cent, it has been estimated that from one hectare, 5 tonnes of oil or 32,000 kWh of electricity could be obtained per year. We do not have large areas of land which do not have a better alternative use which could support such plantations now. It is, therefore, not foreseen that any significant energy contribution can be obtained through this process in the years upto 1990-91.

Geo-thermal energy

4.28. Hot springs, which are the sources of geo-thermal energy occur in four regions in the country, viz. (1) N.W. Himalayan ranges covering areas in Ladkh, Himachal Pradesh, Punjab and U.P. (2) Narmada-Sone Valley (3) Damodar Valley and (4) the West Coast. Explorations primarily at Manikaran and later in the West Coast have been included in the UNDP country programme which envisages geological, geo-physical and geo-chemical surveys, initially by surface explorations followed by appropriate well drilling and testing programmes. Another programme for exploratory work in respect of other areas in N.W. Himalayas and Narmada-Sone areas has also been drawn up by the NCST Expert Group on natural resources. Preliminary analysis reports indicate that out of 253 springs in the country, 103 are Hot, having a temperature above 37°C. The Hot Springs Committee 1966 had considered the Puga springs in Ladakh and Manikaran in H.P. as the two most prospective geo-thermal fields in India. The optimum power generation possible at Manikaran taking into account estimated rate of flow, pressure and temperature was estimated by them at 350 kW. Their rough estimates for Puga and Cambay were 400 kW and 1850 to 2300 kW respectively. Even though quantitatively geothermal energy is not very important in India, some of these sources like Puga in Ladakh have locational advantage which cannot be ignored. In June—September 1973 the GSI led a multipurpose drilling exploration in Puga Valley with specialised assistance from NGRI, AMD, IIT Kanpur, IIT Delhi and Roorkee University. This project consisted of shallow drilling operations at about 15 sites. Central heating by geothermal energy was also successfully demonstrated. The exploration experience from Puga multipurpose project indicates that the total power potential in geothermal energy may be several megawatts.

Tidal power

4.29. An expert panel of the National Committee on Science and Technology has examined the tidal data and indicated the following promising sites (i.e. tidal range above about 5 metres) for tidal power generation:

Area	Approximate potential power output (MW)	Spring Tidal Range
1. Bhavnagar (Gulf of Cambay)	460	10·8 metres
2. Navalakhi (Gulf of Kutch)	123	7·5 metres
3. Diamond Harbour (Hooghly river)	56	5·9 metres
4. Saugar (Hoogly river)		4·9 metres

Subsequent examination proved that the total potential of tidal power would be around 300 MW. The Gulf of Cambay appears to have the maximum power potential but problems of situation will have to be overcome. At Navalakhi siltation is low which makes it a more favourable area though extensive survey data is called for. However, before any tidal power potential can be tapped, considerable preparatory action including the design and manufacture of a suitable turbine is necessary.

Wind mills

4.30. The potential in wind mills has been broadly assessed by considering extensive wind data available with the Indian Meteorological Department from over 400 meteorological stations in the country. Wind mills can be installed for operation in such parts of the country where wind speeds of over 10 kmph are prevalent, e.g., parts of coastal regions, Rajasthan, Gujarat, Maharashtra and Mysore. Whilst suitable wind mill designs have been developed by NAL, they have not been popularised because extensive field trials to demonstrate their technical/economic viability when put to specific applications have

not been conducted. Demonstration projects for extensive field trials of clusters of wind mills for pumping for and power generation applications have been worked out by an NCST expert panel. Whilst NAL have wound up all work on wind mills, CAZRI, Jodhpur and Auroville School of Environmental Studies, Pondicherry are at present actively working on research projects. CPRI has also started work on wind electric generator. The NCST panel has also recommended that design drawings indigenously available for foreign 5—10 kW wind electric power generators be studied to examine whether a few could be manufactured and installed at a favourable location to establish and demonstrate its techno-economic viability.

Chemical sources of energy

4.31. The NCST had constituted an expert panel to assess the potenital in chemical sources of energy. The panel has indicated that major thrust of R & D efforts should be directed to those areas of application, which could lead to reducing dependence on petroleum products, such as motor gasoline, HSDO, kerosene, and non-commercial sources of energy. The group has identified the following as potential areas for further work:

(i) Battery powered vehicle, initially based on lead acid battery.

(ii) Fuel Cells, Rural electrification, particularly of villages having a population of 500 and below: To meet the objectives of these programmes, the development on the following advanced chemical energy sources have been identified—

(a) Development of Sodium Sulphur Battery

(b) Development of Metal-Air Cell

(c) Development of H_2O_2 Cell

(d) Development of Lithium Cell.

Non-Commercial fuels

4.32. Nearly one half of the total energy consumed in the country comes from non-commercial sources such as firewood (including charcoal), cowdung and vegetable waste. The dependence on these fuels is maximum in the domestic sector. This has led to large scale denudation and destruction of forests. Out of the total geographical area of 3.27 million sq km, forests in India occupy about 0.75 million sq km (i.e. about 23 per cent). The percentage of forest area to the total land area as well as the per capita forest area in India is much lower than the world average. The National Forests Policy Resolution laid down that the area under forests be steadily raised to 33.3 per cent of the total geographical area, the proportion to be aimed at being 60 per cent in hill regions and 20 per cent in plains. The area under forests during 1960-61 and 1969-70 and its break-up according to the exploitation, legal status, composition and ownership is given in Table 4.8.

TABLE 4.8

Area under Forest in thousand hectares

Description	1960-61	1969-70*
1. *From point of view of exploitation*		
(a) Exploitable	46,590	45,580
(b) Potentially exploitable	10,020	14,760
(c) Others	10,270	14,690
Total	68,960@	75,030
2. *By ownership*		
(a) State	65,240	71,170
(b) Corporate bodies	2,290	2,480
(c) Private individuals	1,430	1,380
Total	96,960	75,030
3. *By legal status*		
(a) Reserved	31,610	38,070
(b) Protected	24,060	24,450
(c) Unclassed	11,210	12,510
Total	68,960@	75,030
4. *By Composition*		
(a) Coniferous	4,430	4,180
(b) Broad leafed	64,530	70,850
(i) Sal	11,350	11,300
(ii) Teak	8,750	7,340
(iii) Misc.	44,430	52,210
Total	68,960	75,030

*Provisional.

@Includes 2·08 million hectares for which details are not available.

Source: India 1973.

4.33. The statewise distribution of the forest area is given in Table 4.9:

TABLE 4.9

Statewise Distribution of the forest area in India in 1969-70

State/Union Territory	Forest area (Million hectares)	% of forest area to geo-graphical area	Exploi-table area (forest in use)	Poten-tially exploi-table area
1. Andhra Pradesh	6,512	23·53	4,836	1,676
2. Assam (including Meghalaya & Mizoram) ..	4,442	36·38	1,509	200
3. Bihar ..	@@3,059	17·59	2,107	952
4. Gujarat ..	1,800	9·18	1,513	..
5. Haryana ..	142	3·21	57	30
6. Himachal Pradesh	2,159	38·78	1,203	447
7. J. & K. ..	2,105	9·47	1,858*	246
8. Kerala ..	1,269	32·66	108	244
9. Madhya Pradesh	16,813	37·97	10,1[illegible]2	3,987
10. Maharashtra ..	6,696	21·76	3,829	2,471*
11. Mysore ..	3,510	18·30	2,615	895
12. Nagaland ..	290	17·54	31	207
13. Orissa ..	6,746@	43·29	5,383	1,042
14. Punjab ..	202	4·01	90	..
15. Rajasthan ..	3,760@	10·99	2,810	..
16. Tamil Nadu ..	,210	16·99	1,419	791
17. Uttar Pradesh	4,872@	16·55	3,462	701
18. West Bengal ..	1,183	13·47	1,080	65
19. Manipur ..	602	26·92	291	311
20. Tripura ..	630	60·11	240	190
Union Territory				
1. A & N Island ..	747	90·11	503	243
2. Dadra & Nagar Haveli ..	21	42·86	21	..
3. Delhi ..	5	3·36	3	..
4. Goa, Daman & Diu ..	105	27·56	95	10
5. Arunachal Pradesh ..	5,154	61·67	34	52
6. Others ..	..	..	..	..
7. All India ..	75,033	22·87	45,579	14,760

*Estimated. @1968-69 figure repeated.

@@1967-68 figures repeated.

Source—Task Force on Forest Development.

4.34 The main object of forestry development is to meet the immediate and long-term agricultural and industrial requirements since the demand for various forest products, timber, domestic fuel and raw materials for industries has increased rapidly. Consumption of industrial wood in 1968-69 was estimated at 11 million cubic meters while the demand by 1973-74 is projected at 16 to 17 million cubic meters. It is expected that the supply may be increased to 13.5 million cubic meters by 1973-74 leaving a deficit of 2.5 to 3.5. million cubic meters of timber required for industrial use alone. Table 4.10 shows the quantity of timber and firewood produced during selected years in the period 1950-51 to 1969-70:

TABLE 4.10

Production of Timber and Firewood

(Quantity in 000' cubic meters)

Year	Timber wood	Fuel	Total
1950-51	3,843	11,948	1 5,791
1955-56	4,157	10,810	14,967
1960-61	5,428	11,644	17,072
1965-66	8,610	12,094	2,704
1969-70	8,930	12,860	21,790

Source : Task Force on Forest Development.

4.35 The recorded fuel wood output in 1969-70 was 12.86 million cubic meters or about 9 million tonnes. The actual consumption of firewood is, however, reported to be of the order of over 100 million tonnes, the balance of over 90 million tonnes coming from unrecorded fellings and removal from 'treelands' outside the forest area. It has been estimated that upto 1985 the output of fuelwood from forests would increase at the rate of 0.5 million tonnes per year as a result of conservation and protection measures. With the creation of plantations of fast growing species likely to yield about 17.5 million tonnes more, the total availability from recorded fellings might go upto about 35 million tonnes. If strict control is not exercised, unrecorded removal of wood from forests and fellings in 'treelands' might continue at the present rate of about 90 million tonnes or go down slightly giving a total availability of about 120 to 125 million tonnes by 1985. The forecast of the demand is somewhat higher. In view of this, a serious shortage in the availability of firewood is apprehended if afforestation programmes with quick growing species of fuel wood are not taken up immediately on a large scale or if the use of firewood/charcoal is not discouraged by popularising substitute fuels.

4.36 The other major non-commercial fuel in India is cowdung. As this is mostly obtained free of cost and from cattle owned by the villagers, no reliable record of the quantity is available. But it is possible to get a judgement of the level of availability from the population of cattle and the normal yield of dung per annum per animal. The 1966 Cattle Census estimated the total cattle population to be about

230 million animals. An NCAER study has projected the level of cattle population as 280 million numbers by 1975-76. Taking the 1966 population of cattle and the assessment made by field studies that the average yield of dry dung per day per animal as 2 kg, (10 kg wetdung) the annual yield can be estimated to be 170 million tonnes of dry dung. It is, however, necessary to note that only 10 per cent of the cattle population is stabled and the rest of the animals are left astray in the forests and fields most of the time. It is difficult, therefore, to estimate the quantity of dry dung that could be recovered for use. The level of consumption of dung in 1965 is 61 million tonnes. 50 per cent of dung production may be taken as the limiting level of possible use.

4.37 In the case of vegetable waste such as rawdust, paddyhusk, coconut shells, bagasse, dry leaves etc., also, there is not likely to be any availability constraint in view of the projected increase in agricultural output. However, bagasse which is one of the vegetable waste products most widely used as fuel both in the domestic sector as well as in industries like sugar mills, has got a much better use as a raw material for paper manufacture. The availability of dry bagasse is estimated at 14 per cent of the total quantity of sugarcane crushed. About 130 million tonnes of sugarcane is grown now of which at least 100 million tonnes is crushed for sugar, khandsari or jaggery manufacture. Availability of baggasse may be assumed as 14 million tonnes. In view of the need to divert baggasse for industrial use, this resource is not to be counted upon for fuel purpose. There are no records to show the quantity of other vegetable wastes that would be available.

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CHAPTER V

REGIONAL DISTRIBUTION OF DEMAND FOR ENERGY

5.1. In a large country like India, efficient development of energy resources would call for, not merely a reliable forecast of the level of demand for different fuels in the country as a whole, but some broad pattern of the likely spatial distribution of this demand among the different regions of the country. There have been very few attempts* in the past to make any systematic study of energy consumption at the regional or State level. Most of the past data in reliable official records relate to energy consumption in the country as a whole, the only exception being electricity data which is available state-wise. The reorganisation of States, the difference in the quality of statistics compiled in the different States, the lack of past data in some union territories make a study of the regional energy consumption in the past very difficult. The Committee felt that in spite of the serious limitations of data, a study of the past trends in the energy consumption in the different regions should be attempted and the likely future distribution of demand for energy as between the regions indicated.

Regions for Energy Studies

5.2. For the purpose of this Report, the country has been divided into four regions which closely correspond to the five regions adopted for power planning purposes with the aggregation of East and North-East into one region. The lack of reliable past data of the consumption of different fuels and the difficulties of projecting demand for the North-Eastern region have prompted the adoption of a simpler four region classification as follow:—

Region		*States which comprise the region
Northern Region	..	Uttar Pradesh, Rajasthan, Punjab, Haryana, Himachal Pradesh, Jammu and Kashmir.
Eastern Region	..	Bihar, West Bengal, Orissa, Assam (including Meghalaya, Mizoram and other States).
Western Region	..	Madhya Pradesh, Maharashtra, and Gujarat.
Southern Region	..	Andhra Pradesh, Kerala, Mysore and Tamil Nadu.

*The want of adequate data, the Union Territories hav ot been included.

5.31. The first step in the projection of the future energy demand is the study of the past trends in the consumption of energy in different regions. (It is relevant to state here that in the regional demand studies, non-commercial energy consumption has been included). Tota commercial energy consumption in the different regions and the consumption of different fuels from 1960-61 to 1970-71 is summarised Table 5.1.

TABLE 5.1

Statement of Commercial Energy Consumption—Regionwise from* 1960-61 *to* 1970-71

(Figures in meter)

	Regions			
	Northern	Eastern	Western	Southern
1960-61				
Total C.E. Consumption	13·16	23·90	22·43	14·47
(a) Coal	4·43	12·60	4·01	1·66
(b) Oil	6·58	7·18	14·31	9·06
(c) Electricity ..	2·15	4·12	4·16	3·75
1965-66				
Total C.E. Consumption	25·58	38·42	39·52	25·40
(a) Coal	7·90	19·20	7·70	2·50
(b) Oil	11·92	12·24	24·28	16·50
(c) Electricity ..	5·76	6·98	7·54	6·40
1970-71				
Total C.E. Consumption	39·78	42·92	56·65	38·38
(a) Coal	8·20	17·90	8·90	2·80
(b) Oil	20·65	14·54	34·01	23·32
(c) Electricity ..	10·93	10·48	13·74	12·26

*Consumption by Railways and the consumption in Union Territories are not included.

5.4. It is interesting to examine the percentage share of each region in total commercial energy consumption and compare the results with the

*The noteworthy exercises in this regard are those made by Energy Survey Committee (1965) and the studies of the N.C.A.E.R of the Energy Demand for different regions. The former is a sketchy one while the latter assumes that the rate and pattern of industrial development in different States would be the same as suggested by N.C.A.E.R. in the earlier reports on the industrialProgramme of different States.

percentage share of population. Table 5.2. sets out the results.

TABLE 5.2

Percentage distribution of energy consumption Regionwise during 1960-61 *and* 1970-71

Region	Percentage of commercial energy consumption of the total commercial energy consumption	
	1960-61	1970-71
Northern	18 (27·06)	22 (26·73)
Eastern	32 (22·51)	24 (22·44)
Western	30 (21·06)	32 (21.65)
Southern	20 (25·13)	22 (24·67)

NOTES (1) Figures in brackets indicate percentage of total population in each region.

(2) The figures in brackets do not add upto 100 as population of Union Territories is excluded

5.5. In 1960-61, the Eastern and the Western regions, which had only 22.5 per cent and 21 per cent of the total population, consumed about 33 per cent and 31 per cent of commercial energy; while in the Southern and the Northern regions the percentage share in population was larger than the percentage share in energy consumption. By 1970-71, a more equitable distribution of energy consumption was attained. Percentage share of the Southern and the Northern regions increased; but between the Eastern and the Western regions, the latter came to occupy the first position as the largest consumer of commercial energy even though resourcewise the Eastern region was better endowed with energy resources and the Western was the poorest of the four regions. From general observation, it may be stated that within the Western region, the Eastern part has energy resources while the energy demand has come up in a large way in the Western part of the region.

5.6. An analysis of the rates of growth of commercial energy consumption in the defferent regions during the ten year period between 1960-61 and 1970-71 and during the two semi-decades that comprise this period shows interesting facts as given in Table 5.3.

TABLE 5.3

Regionwise rates of growth of consumption of commercial energy

(Figures in % per year)

Region	1960-61 to 1965-66	1965-66 to 1970-71	1960-61 to 1970-71
Northern	14·2	9·2	11·7
Eastern	10·0	2·2	6·0
Western	12·0	7·5	9·7
Southern	11·9	8·6	10·2

5.7. The growth in commercial energy consumption was moving along the right direction during 1960-61 to 1965-66. In the latter half of the decade, the Eastern region suffered a severe industrial recession. As a result, by the end of the Sixties, the Western region which is the poorest in energy resources emerged as the highest consumer of commercial energy.

5.8. Per capita consuption of commercial energy in 1960-61 and 1970-71 is shown in Table 5.4.

TALBE 5.4

Percentage consumption of commercial energy (excluding Railways) Regionwise 1960-61 *and* 1970-71.

(Figures in tonne of coal replacement)

	Per capita consumpstion of commercial energy in	
	1960-61	1970-71
Northern	0·107 (65·2)	0·265 (81·8)
Eastern	0·208 (126·8)	0·302 (93·2)
Western	0·239 (145·7)	0·477 (147·2)
Southern	0·129 (73·2)	0·281 (86·7)

NOTE (Figures in brackets represent the index of per capita consumption with All-India per capita consumption=100)

By the beginning of the Seventies, the per capita consumption of energy has evened out a little in all the regions except the Western region.

5.9. The Committee's studies reveal that there was a large increase in commercial energy consumption over time per unit of national income during the decade of the Sixties. This is due to the intensity of energy use increasing in the mining and manufacturing sector as well as in agriculture sector. There are difficulties in separating the influence of different factors which influence the growth of commercial energy consumption. During the period 1965-66 to 1970-71 the income from mining and manufacturing sector grew in all the States (and regions) at lower rates than in the earlier semi-decades, but the State incomes in many States grew at a higher rate. The commercial energy consumption in all the States increased at a lower rate during the latter half of the Sixties as compared to the earlier half.

5.10. **Projection of future demand**—Based on the survey of regionwise past trends of commercial energy consumption, the possible rates of growth of such consumption in the future could be attempted. On the basis of Case-II estimates mentioned in Chapter III, the total commercial energy demand is estimated at 898 mtcr

by 1990-91. The distribution of this total demand between the different regions could be attempted by—

(a) projecting the demand on the basis of past correlation between energy consumption and regional incomes and using the regression models to project future consumption assuming certain levels of income growth; or

(b) by working out the picture of possible growth in different sectors in each region and computing the energy needs for each sector; or

(c) by assuming certain policy objectives regarding energy consumption in future.

5.11. The Committee examined all the alternatives. Several regression models correlating total energy consumption, and consumption of different fuels with economic indicators were considered. In most of the cases the correlation was not significant. Further, the Committee felt that an extrapolation of the past trend would only perpetuate regional imbalances in energy consumption. The regression model would still leave the question of choosing alternative patterns of economic growth in different regions (which provide the explanatory variables) to subjective considerations. The second method listed above would call for economic development plan for different regions being worked out by the Committee, which is beyond the terms of reference of the Committee. The third method of projecting the distribution of energy demand in different regions by assuming certain policy objectives involves first the prescription of the policies. The Committee is not in a position to suggest regional policy objectives in the energy sector without intergrating these policies with the overall policies for regional development or industrial location policies to be adopted by the Government. But a hypotetical exercise of what is likely to be the trend in consumption in different regions if the policies were framed so as to ensure equalisation of per capita commercial energy consumption in different regions within a given time frame was attempted merely to show the extent of modifications to current trends that such a policy would call for. It was assumed that per capita commercial energy consumption would be a broad representative measure of the per capita income in the different regions and that a policy would be operated to remedy regional imbalances in such a manner that it would be reflected ultimately in the per capita energy consumption in different regions being equal. It was further assumed that by 1990-91, the regional imbalances would be corrected in this manner. The conclusions of this exercise are presented not as a recommendation that action should be taken in this direction but to indicate the changes in trends of energy consumption that would be called for and to recommend the formulation of overall policy towards regional development and particularly for an industrial location policy.

5.12. This exercise involved first the projection of population of the different regions upto 1990-91. No official estimates of population in different regions upto 1990-91 have been made. Some tentative estimates were made by the Committee on the basis of available information.

TABLE 5.5

Estimated Regionwise Population

(In million)

Region	(a) 1970-71	(b) 1978-79	(c) 1990-91
Northern	150·1	180	213
Eastern	142·2	167	197
Western	118·8	137	162
Southern	136·7	153	181
Total ..	547·9	637	755

(a) 1071 Census

(b) As indicated in the long-term perspective included in the Draft Fifth Plan Regional break-up made on the lines of Expert Commitee on Population projects.

(c) Assuming the same rate of growth of population in all the regions and the rate of growth indicated for the Period 1981-86 in the Draft Fifth Plan to continue for the next 5 year period also.

5.13. Based on these tentative estimate of population in different regions and the assumption that per capita consumption of commercial energy for all the regions should be equal, the distribution of energy consumption as between the different regions was computed. The rates of growth of commercial energy consumption that this would imply in the period 1970-71 to 1990-91 were compared with the past growth rates in commercial energy consumption. The results of this study are set out in the Table 5.6.

TABLE 5.6

Estimates of regionwise consumption of commercial energy and the implied rates of growth of consumption.

	Energy consumption in million tonnes of coal replacement in		Rate of growth %			
			Implied between 1970-71 and 1990-91	Actual		
	1970-71 (Actual)	1990-91 (Anticipated)		1960-61 to 1970-71	1960-61 to 1965-66	1965-66 to 1970-71
1	2	3	4	5	6	7
Northern ..	29·78	254	9·7	11·7	14·2	9·2
Eastern ..	42·92	235	8·9	6·0	10·0	2·2
Western ..	56·65	193	6·3	9·7	12·0	7·5
Southern ..	38·38	216	9·0	10·2	11·9	8·6

5.14. When the 'normative'* rates of growth computed above are compared with the rates of growth of commercial energy consumption in the decade of the Sixties, it is found that in all the regions except the Eastern region, the rate has to slow down. When the 'normative' rates are compared with the rates of growth of commercial energy consumption during 1965-66 to 1970-71, it is seen that all regions other than Western region has to increase the rate. The rates of growth indicated for the period upto 1990-91 in the case of Northern and Southern regions are slightly above the rates registered in the later half of the Sixties; but in the case of the Eastern region a big increase in commercial energy consumption is called for while the Western region has to sharply reduce the rate of increase in commercial energy consumption. The regulation of the growth rates in the coming years to the levels indicated will have serious implication on the development plans of the different regions, especially the Western region, where the rate of growth has to be reduced.

Fuelwise consumption of commercial energy in different regions

5.15. While the per capita commercial energy consumption in the different regions might tend to become equal with policy measures, the composition of fuels which makes up total commercial energy consumption, may vary from region to region depends largely on the relative availability and prices of the fuels. It is reasonable to assume that in the natural course, the regions which have abundant coal resources will use relatively more coal than oil in their energy utilization. But the levels of utilization will also depend on the policies of the Government regarding setting up of different types of industries in different regions. As the industrial policy has no clear guidelines to industrial location and regional development and as it is not possible at this stage to forecast possible changes of Government policy in this regard, it has not, however, been possible to estimate the possible levels of consumption of specific fuels like coal, oil and electricity.

Conclusions

5.16. As between the regions of India, energy consumption is not very balanced, whether we consider the per capita consumption or the consumption per unit of national income. While the imbalances are slowly getting adjusted, the Western region is emerging as a high consumption region in respect of commercial energy. *If the objective is to achieve a more balanced per capita total commercial energy consumption by 1990-91, there should be a well conceived policy towards regional development which will take note of the divergenees in resource endowments. The regionwise energy policy should be a part of a well-conceived regional development strategy.* The figures provided in the Report above should be taken as merely illustrative and cannot be regarded as a recommendation with any operational content.

* The rates shown in Col. 4 in Table 5·6 are referred to as Normative rates for Commercial.

CHAPTER IV

PERSPECTIVE OF LONG ENERGY PROBLEMS

Energy Plan and National Development Plan

6.1. The preceding chapters have described past trends in energy consumption in India, the relationship between energy consumption and indices of economic growth, the likely demand for energy and demand for specific fuels in the coming years upto 1990-91, the energy resources available in the country and the regionwise supply and demand position.

Energy Consumption

6.2. If we take the period from 1953-54 to 1970-71 total energy consumption increased from 193.5 million tonnes of coal replacement to 376.6 million tonnes. The share of non-commercial energy in total energy used declined from 17.5 per cent in 1953-54 to 48.5 per cent in 1970-71. The pattern of growth in the energy section outlined in this Report would take total energy consumption to 1079 million tonnes of coal replacement in 1990-91. Of this the consumption of non-commercial fuels would be only 181 million tonnes of coal replacement i.e, 16.8 per cent. In per capita terms, total energy consumption in India will increase from 0.509 tonne in 1953-54 and 0.676 tonne in 1970-71 to 1.439 tonne in 1990-91, in terms of commercial energy consuption along, per capita consumption would increase from 0.158 tonne in 1953-54 and 0.361 tonne in 1970-71 to 1,200 tonnes by 1990-91. It is relevant to note that this figure understates the total energy utililized in the country as the large quantity of animal power still used in India for providing motive power is completely left out in these calculations.

Basic directions of energy policy

6.3. While a review of the fuel policy is essential to decide from time to time the magnitude of the production efforts required and the investment decisions called for, the studies of the Committee have brought out some fundamental direction of fuel policy which may remain invariant under most of the likely developments in the future. It would be useful to recount these even at this stage.

6.4. We can glean the trends in energy consumption beyond 1990-91 by tracing the factors which affect the quantity and composition of energy consumption. In a modern economy energy is used mainly for the following purposes:—

(1) heat raising
(2) lighting
(3) the provision of motive power and
(4) electrolysis

The demand for the first three purposes arises in house-holds, industrial enterprises, transport undertakings and commercial enterprises. The demand for the last mentioned purpose is restricted to a limited class of industrial enterprises.

6.5. In India, the household demand for energy for heat raising arises mainly for the purposes of cooking and lighting. The total quantum of energy demand for cooking may not rise much faster than the rate of growth of food consumption; but the preferred sources of energy for this purpose may change as the economy develops. For instance, with growing urbanisation, electricity, gas of kerosene will tend to replace non-commercial fuels like cowdung and firewood as the source of energy for cooking. The bulk of this urbanisation would probably have worked itself out by 1990-91.

6.6. Household demand for energy for lighting may well have a higher income elasticity than the demand for energy for cooking. In this case too one can expect a gradual change in the preferred sources of energy for this purpose—mainly a substitution of electricity for kerosene. Here also, most of the structural changes in energy demand would have been effected by 1990-91. Even by 1990-91 a substantial portion of the rural households may still have incomes which will make them dependent almost entirely on fuels which could be obtained at no private cost. But utilisation of such fuels unless properly regulated will have very high social cost. In order to reduce the social costs a number of institutional arrangements and research efforts have to be undertaken to ensure that the optimal utilisation of locally available fuel resources (vegetable waste, animal dung, solar energy etc.) is evolved. Suitable measures may have to be taken up in this direction even from now as indicated in Chapters X and XII.

6.7. Household demand for energy for motive power may also be highly income-elastic. Apart from anything else, the growth in the urbanisation will *ceteris panibus* tend to increase demand on this count. However, with rising incomes there may be a substitution of inanimate for animate energy e.g., as would arise in the switchover from bicycles to scooters. But the level of demand on this count would depend greatly on governmental policy with respect to the private operation of vehicles, the importance attached to public transport, the location of offices and factories with respect to residences etc. If the right policies are followed. India will not experience the sort of burst in energy demand on this count that was

experienced in U.S.A., Western Europe and Japan. The rate of growth of demand may not accelerate for quite a long period even after 1990-91.

6.8. The demand for energy for agricultural operations arises mainly for the purposes of providing motive power. With the gradual intensification of agriculture, the level of demand for this purpose is likely to increase. Moreover, a substantial measure of substitution of inanimate for animate power is taking place and will continue to take place. But the greater part of this substitution will probably have been effected by 1990-91.

6.9. The demand for energy for industrial operation arises mainly for the purposes of heat raising, for providing motive power and for electrolysis. The level of energy demand for this purpose will depend essentially on the structure of industrial production. Within any given industry the level of energy demand per unit of output will not in general change substantially. The high rate of growth of energy consumption in industry over the past two decades reflects the growing importance of basic metals and chemical products in the total industrial output. In industry, the use of energy for the purposes of heat-raising and electrolysis probably increases faster than the use of energy for motive power as the economy grows. However, the impact of such structural changes on the level of energy demand may well be more moderate in the period beyond 1990-91. The source of energy used for these purposes will also change if the policies recommended in this Report are implemented. Here too, the bulk of the changes may well have been effected by 1990-91.

6.10. In the transport sector, energy is used almost entirely for the purpose of providing motive power. As the economy grows, the demand for transportation will most certainly increase, but the magnitude of the increase will depend greatly on the locational aspects of development. If, as is likely, the degree of specialisation of different regions in different types of production increases, the demand for transportation will increase at a rapid pace. But there is no reason for supposing that such trends towards specialisation will be more pronounced after 1990-91 than before. Hence, on this count too, the rate of growth of demand for energy may not accelerate after 1990-91.

6.11. *The considerations described above suggest that the rate of growth of energy demand in the period beyond* 1990-91 *may not be as high as the projected rate of growth of energy demand* upto 1990-91 *and certainly not as high as the growth rates observed over the past two decades.* Most of the substitutions of one energy source for another that are taking place or that are recommended in this Report would have been effected by 1990-91 and the rate of growth of demand for individual forms of energy will also reflect mainly the income-elasticity of demand for that form.

6.12. Electricity will be the principal form of energy for the purposes of lighting and of course the sole form for electrolysis. It will be used for motive power in many applications, particularly those involving stationary equipment. The use of electricity for motive power for vehicular purposes may turn out to be important in the period beyond 1990-91 if current research work on battery-operated vehicles yields results. There will be some use of electricity for heat raising.

6.13. Coal will be used mainly for the purposes of heat raising including, of course, heat raising in thermal power stations. In view of its low efficiency, the use of the steam locomotive may decline unless research work leads to some dramatic technological developments.

6.14. Oil products are a particularly suitable form of mobile energy with a high energy to weight ratio. If the recommendations of this Report are accepted, they will be used mainly as a source where such a mobile source of energy is necessary—for lighting and cooking in areas where electricity and solid fuels cannot be made available and for motive power in road transport. Oil products are too expensive a source of energy for purposes for which coal and electricity can be used.

6.15. On the supply side, among the commercial fuels, coal will remain the most important supplier of energy in India upto 1990-91 and most probably even beyond. The oil resources in the country have not been fully exploited. The oil bearing area that has been studied thoroughly constitutes not more than 4 per cent of the total area of the Indian sedimentary basin which could be the habitat for oil. But it must also be remembered that this 4 per cent has been considered the most promising on the basis of the knowledge that we have now. While the possibility of finding more oil on-shore off-shore should not be ruled out, it will be irrational to frame a policy on the basis of the likely findings of oil.*

6.16. As indicated in Chapter IV there are also possibilities of our exploiting very large quantities of natural gas resources from the areas under exploration within the country and abroad. Increased availability of natural gas will call for changes in the pattern of fuel supply suggested in this Report. At this stage, however, it is too premature to make any attempt to quantify the possibilities.

6.17. Between 1983-84 and 1990-91, it is anticipated that Fast Breeder Reactor technology (F.B.R.) would be commercially available to India. The availability of economically viable,

*"In fact, if oil is found in the country, whether it should be used internally or exported would have to be carefully decided with reference to the other fuel forms available in the country, the relative price of fuel in the international market and our other import needs.

commercial scale; Fast Breeder Reactors in the country would introduce a new element in the energy supply situation which has not been fully taken note of in our Report. *Given the very large resources of thorium and the definite possibility of accumulating significant quantities of plutonium in the country by* 1990, *India would be poised for a very fast growth of nuclear power poduction when FBR technology is commercialised.* The Department of Atomic Energy has drawn up plans to increase nuclear power generation capacity from 1900 MW in 1983-84 to 8623 MW in 1990-9-. Of this 6620 MW will be based on the first generation heavy water reactors of the kind which are already being built while 2,000 MW will be based on Fast Breeder Reactor technology which is under development. The Committee would welcome such rapid increase in nuclear power generation, especially, power generation based on FBR technology as in the years beyond 1990-91. It will be very difficult to meet the power requirement without adequate support of supply from FBRs. If the pattern of supply of fuels recommended in this Report materialise by 1990-91, almost the entire hydel potential would have been exploited and coal production would have reached a level that there would be severe limitations to further rapid increase in its production; if no large oil reserves are discovered by then in India, the incremental demand for energy beyond 1990-91 would have to be met by nuclear power generation. This would be possible only if FBR technology for commercial operations is available by then. *In view of this, Committee would strongly recommend that adequate effort shouuld be put in developing this technology based on the use of thorium from now on.*

6.18. The other energy resources, which are not commercially utilised in significant quantities anywhere in the world but which are talked about with great hopes, are geothermal energy, solar energy, wind power, tidal power and chemical sources of energy. The Committee examined carefully the status of work and the likely contribution that could be obtained from these sources. The total energy available from tidal power and the geothermal energy that could be tapped on the basis of the present technology appears to be insignificant. Similarly, the contribution of wind power is likely to be small even if a very large number of wind-mills are set up in the country. There are grave uncertainties regarding the commercial use of solar energy for industrial needs. The Committee therefore felt that by 1990-91, the contribution from these non-commercial energy sources is not likely to be significant enough to be taken note of in discussing the energy supply situation. But in certain specific locations, these non-commercial energy forms may have some relevance. *The Committee, has, therefore, recommended the support for all research and development activities connected with the utilisation of non-conventional energy forms.* Beyond 1990-91, there may be possibilities of energy which appear the only non-comsolar energy which appear the only non-commercial sources of energy which could contribute to supplies in a substantial way.

Minimisation of Energy Cost

6.19. Upto the early seventies, all over the world the trend was not only to plan for adequate energy supplies but to provide it at minimum of cost. Minimisation of energy cost was one of the primary objective of energy planning in many countries but the shortages and uncertainties in oil availability during the last few years has shifted to emphasis in energy planning to ensuring the adequacy of fuels more than the reduction of energy cost. In the coming years when the oil situation in the international market settles down to normal conditions, there will again be a renewed emphasis on minimisation of energy costs. If India's production is to be competitive in the international market, we should ensure that our planning for energy industries and operation of these industries are comparable in efficiency to that obtaining in other countries. The Committee has emphasised throughout the Report the need for cost minimisation. Any investments made in the energy sector which would produce high cost energy and which would have productive life beyond 1990-91 will make it very difficult to reduce the overall cost of energy production. Hence, however, urgent be the compulsion of the current situation, we should not commit ourselves irrevocably to such high cost investments.

6·20. There are indications that a number of technological developments in the coming decade will reduce the transportation cost of energy. Unless we are alert and adopt the most modern and the most optimal technologies for transporting energy, the cost of energy to the consumer in India is likely to be higher than the cost elsewhere. In a country of continental dimensions like ours with coal resources situated mostly in the Eastern and Central regions and hydel power concentrated mostly in the Northern region, there will be need to transmit energy in the form of electricity over long distances. *Transmission costs could be reduced by adopting higher transmission voltage as well as the newer technologies like DC transmission or transmission through cryogepic conductors, liquid-filled conductors etc. Research and development in this area should be taken up even from now on, if we are to ensure the supply of power at economic rates to the consumer in the years beyond* 1990-91.

6.21. Another major problem in energy transportation which will continue to be of interest beyond 1990-91 is the transport of coal to different supply points. In view of the continued difficulties in transporting coal, a number of suggestions have been made for transporting coal,

by converting it first as electricity and transmitting it through EHV lines or by gasification of coal or by converting it to coal slurry and transporting it by pipelines. While transmission of power by EHV lines in preference to transporting coal is economical under certain circumstances, the coal gasification and pipeline transport of gas or transporting of coal as slurry by pipeline appears to be un-economical under Indian conditions. While it may be useful to make some detailed studies of the economics of coal gas transport and coal slurry transport in certain specified locations and take up some schemes as part of R. & D. efforts, the contribution of the pipeline mode to coal transport will be very small upto 1990-91. Even if we assume that all power generation will be at the pithead by 1990-91, there will still be a need to transport by rail around 200 m. tonnes of coal need for uses other than for power generation. Pipeline transport, even if this is introduced in certain circumstances, may transport at the most about 10 million tonnes. The major burden of moving coal will have to be borne by the Railways. *The Committee has suggested that the coal transport capability of the Railways should be built up to a level of 85 per cent of the coal production in the country at any point of time. This would mean that the Railways' capability to move coal should be around 300 million tonnes by* 1990-91. While the possibilities of pipeline transport of gas or slurry becoming economic in the circumstances prevailing beyond 1990-91 cannot be ruled out, it is clear that even then the burden on the Railways to transport coal will gradually increase.

Need for review of energy policy

6.22. A number of factors assumed as the basis for our forecasts and recommendations may change from time to time. *It is, therefore, necessary to keep the policy under periodic review and to effect changes wherever necessary.* Energy utilisation represents the culmination of a long process which starts with the exploration for fuels, their transformation and transportation. All these stages which precede energy consumption have long gestation periods. Energy plans should therefore extend to long-term horizons of at least 15—20 years. *If energy plans and policies are to be operationally meaningful, they should be reviewed periodically at least once in three years and the planning horizen extended at each time to 15 years.*

Energy Commission

6.23. *The implementation of the recommendations of the Fuel Policy Committee which call for coordinated action by several Ministries and agencies of the Government. An ideal organizational arrangement for this will be the setting up of an Energy Commission clothed with adequate powers and manned by suitable talents which can be entrusted with the responsibility for the periodic review of the energy situation and for planning for optimal production and distribution of the different fuels.* As the experience of this Committee has revealed that the data relating to sector-wise energy consumption, the effect of related prices of fuels, and the regional energy consumption data are not available, the Commission should also have the responsibility of collecting systematically the information and data on the Indian as well as international energy situation and of organizing research and analysis which will contribute towards the review and, if necessary, the revision of the Energy Policy. *However, it is recognised that such a Commission will have to take over the functions which are now dealt with in several Ministries like the Ministry of Irrigation and Power, the Department of Mines, the Department of Petroleum, the Railway Board and the Planning Commission. It has also to be recognised that the scope of work of the Commission will become very large and some of the problems associated with large organization will have to be faced by the Commission.*

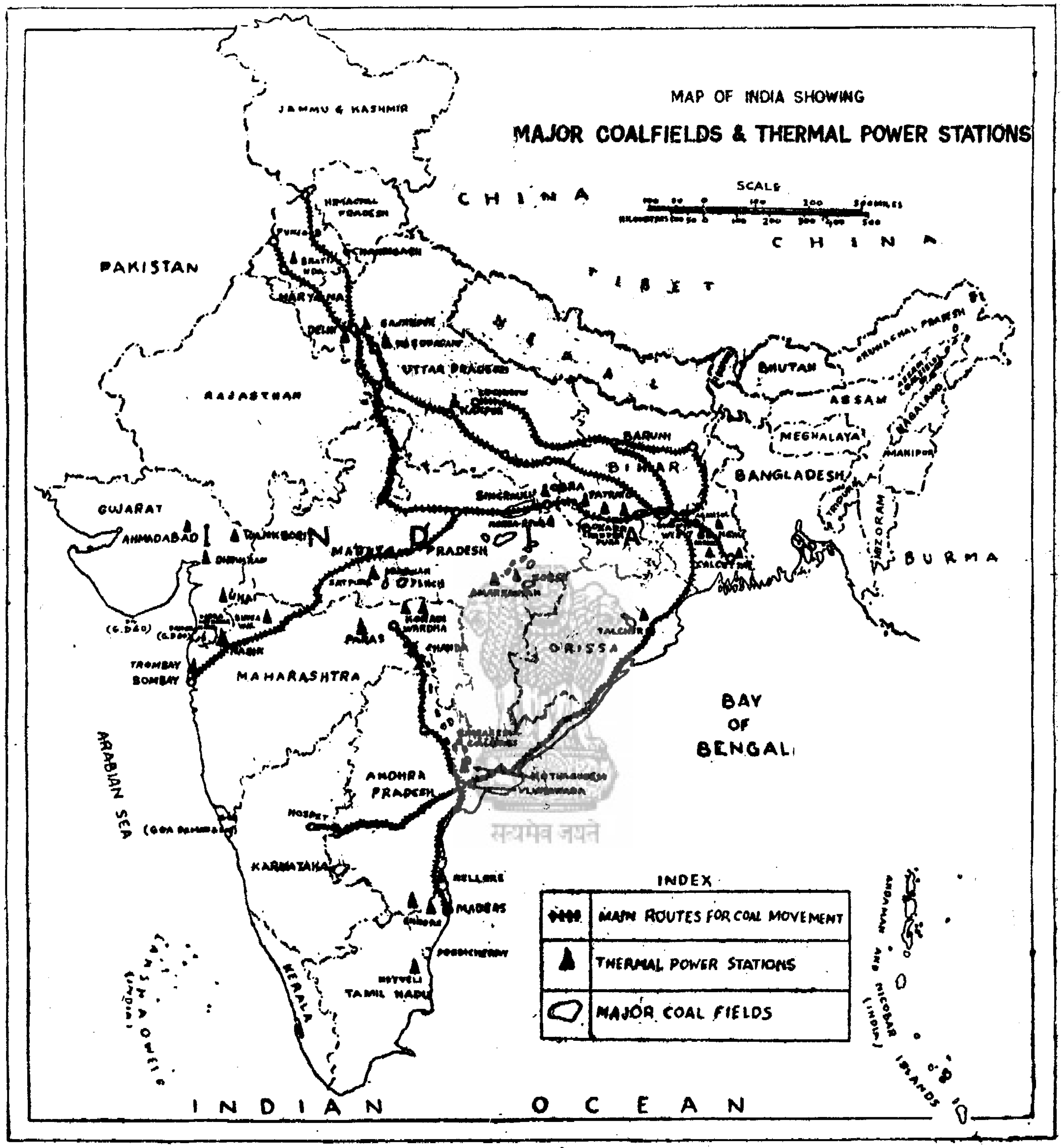
Energy Board

6.24. *The need, however, to coordinate the activities of the different agncies of Government dealing with energy is very urgent. Committee considers that it would be appropriate to immediately set up an Energy Board consisting of the Ministers of the concerned Ministries supported by a suitably structured Secretariat to assist this Board. Such a Board would be somewhat different from a Cabinet Committee as the Board would have a Secretariat which would initiate or undertake studies and analysis relevant for the review or revision of the fuel policy and would not depend entirely on the administrative Ministries for such studies.* The Energy Board can be set up immediately and with the experience gained in its working several functions of the Ministries which are more important for effective discharge of its functions could be transferred to the Board. The case for the Energy Commission could be re-examined at an appropriate stage later.

Institute of Energy Studies

6.25. In the Report on "The Fuel Policy for the Seventies" (May 1972), the Committee recommended that an Institute of Energy Sudies should be organised for collecting systematically the information and data on the Indian as well as international energy situation and of organising research and analysis which will contribute towards the review and, if necessary, the revision of the Energy Policy. If the Energy Board is formed, it may be useful to entrust the functions

of the suggested Institute of Energy Studies to the Board. It should be noted that we have several institutions in the country which are even now engaged in certain aspects of energy production and utilization. Whether a separate Institute of *Energy Studies is set up or the proposed Energy Board takes up the work, the working of the agency entrusted with Energy studies, should be oriented more towards the arranging for the studies to be conducted by different institutions and agencies in existence now and co-ordinating the research projects. Any attempt to centralise the research efforts relating to energy problems which extent over a very large area of economics, science and technology under a single institution may prove counter-productive.*



1. BASED UPON SURVEY OF INDIA MAP WITH THE PERMISSION OF THE SURVEYOR GENERAL OF INDIA. © GOVT. OF INDIA COPYRIGHT, 1975
2. THE TERRITORIAL WATERS OF INDIA EXTEND INTO THE SEA TO A DISTANCE OF TWELVE NAUTICAL MILES MEASURED FROM THE APPROPRIATE BASE LINE.
3. THE BOUNDARY OF MEGHALAYA SHOWN ON THIS MAP IS AS INTERPRETED FROM THE NORTH-EASTERN AREAS (REORGANISATION) ACT 1971, BUT HAS YET TO BE VERIFIED.

CHAPTER VII

COAL POLICY

Coal: Principal source of energy

7.1. Coal was the principal source of supply of commercial energy in India till the early Fifties. Over the last two decades, the direct use of coal has been steadily declining in relation to other fuels and the estimates of demand given in this report indicate that this tendency will continue upto 1990-91. The relative proportions of coal, oil and electricity consumed in the economy and likely to be consumed in future are indicated in Table below :—

TABLE 7.1

Share of coal, oil and electricity in total commercial energy

Year	Coal (Direct Use) %	Oil %	Electricity %	Total
1953-54	47·8	39·6	12·6	100·0
1960-61	39·9	43·4	16·7	100·0
1965-66	35·3	43·9	20·8	100·0
1970-71	26·0	49·3	24·7	100·0
1978-79*	23·5	48·8	27·7	100·0
1983-84*	23·3	45·3	31·4	100·0
1990-91*	21·8	42·9	35·3	100·0

NOTE: Percentage calculated with reference to coal replacement measure.

* As per estimate Case II in Chapter III.

7.2. Though the share of coal directly used in the total commercial energy is going down, the coal used indirectly through transformation as electricity is rapidly increasing. The increasing demand for electricity and the limitation on the possibilities of increasing power generation from hydel and nuclear sources during the period upto 1990-91 leads to an increasing demand for coal for thermal power generation. As a result of this, the quantity of coal used indirectly is likely to increase relative to coal used directly and the share of total coal in total commercial energy is expected to be stabilised around 38 per cent by end of Fifth Plan period. Table below sets out the likely trends:

TABLE 7.2

Share of coal used directly and indirectly in total commercial energy

Year	Total commercial energy	@ Coal used: Direct	In-direct	Total	% share of total coal**
1960-61	101·2	40·4 (85·77)	6·7 (14·23)	47·1 (100)	46·54
1965-66	147·0	51·8 (831·41)	10·3 (16·59)	62·1 (100·0)	42·24
1970-71	197·3	51·4 (77·88)	14·6 (22·12)	66·0 (100·0)	33·45
1978-79*	361·0	85·0 (62·0)	53·0 (38·0)	138·0 (100·0)	38·2
1983-84*	532·0	124·0 (61·0)	80·0 (39·0)	204·0 (100·0)	38·3
1990-91*	907	198·0 (58·0)	144·0 (42·0)	342·0 (100·0)	37·7

**Percentage calculated with reference to coal replacement measure.

*As per estimates (Case-1) in Chapter III. Figures in brackets indicate percentage, share of coal used directly and indirectly in the total coal used.

@Exclusive of coal used for non-energy purposes.

As seen from Table 7.2 the share of coal used for power generation as a percentage of total coal was only 14.2 per cent in 1960-61. This is estimated to go upto 42 per cent by 1990-91.

7.3. However, in international comparisons, the relative shares of coal, oil and hydel electricity are calculated in terms of coal equivalent measures is considered, the share of coal remains above 50 per cent upto 1990-91.

TABLE 7.3

Share of coal used directly and indirectly as per cent of total Commercial Energy (in coal equivalent measures).

Year	Total commercial energy in mtce	Coal used in (a) m. tonnes: Direct use	Indirect use	Total	% share of total coal in c.t.c.e.
1960-61	70·8	40·4	6·7	47·1	66·53
1965-66	102·2	51·8	10·3	62·1	60·76
1970-71	132·0	51·4	14·6	66·0	50·00
1978-79	234·0	85·0	53·0	138·0	58·97
1983-84	357·0	124·0	80·0	204·0	57·14
1990-91	623·0	198·0	144·0	342·0	54·90

(a) Exclusive of coal used for non-energy Purposes.

7.4. Coal demand forecast in this report implies an annual growth of about 12.6 per cent during the Fifth Plan period and about 8 per cent from then on. As a result of the new thrust for substituting of oil by coal in different sectors, and the new technological developments anticipated in the production of chemicals and fertilizers based on coal, the estimate of coal demand forecast for these purposes in the report should be taken as somewhat conservative. (It is to be noted that the use of coal as a feedstock for the manufacture of nitrogenous fertilizer has been taken note of in our forecast; but no other chemical production based on coal has been assumed, as there are grave uncertainties in estimating this). Coal, therefore, will play the most important role in meeting the energy and feedstock requirements of the country. Fortunately, coal, except for the metallurgical variety, is available in quantities which may last for the next 100 years. The production of coal has a long history in the country and the technology of coal production is well developed. *We should therefore consider coal as the primary source of energy in the country for the next few decades and the energy policy of the country has to be designed on this basic premise.*

Survey of coal industry

7.5. While evolving a policy for coal development in this country, it would be appropriate to make a survey of the coal industry. The first published reference to the mining of coal in India dates back to the year 1774 when shallow mines are reported to have been developed in the Raniganj coal field. Systematic mining of coal through quarries or shallow pits seems to have started only in the second quarter of the nineteenth century. By 1860 nearly 50 collieries were in operation, producing about 2.8 lakh tonnes of coal per annum in the Raniganj area. By the end of the nineteenth century the production of coal from the Raniganj field had increased to 2.5 million tonnes per annum but in the meantime other areas had also started producing coal, the most important coalfield being Jharia in Bihar. Coal mining started in Madhya Pradesh (then known as Central Provinces) in 1862, in the Rewa State (now part of M.P.) in 1884, in Singareni (in the then Hyderabad State, now in Andhra Pradesh) in 1887 and in Upper Assam in 1881. At the beginning of the present century, coal production had reached a total of about 6 m. tonnes. The growth of the industry in subsequent years was as follows :—

TABLE 7.4

Growth of Coal Production in India

Year	Coal production in m. tonnes
1900	6·00
1920	17·80
1930	23·80
1940	29·39
1950	32·81
1955	38·84
1960-61	55·70
1965-66	67·66
1969-70	75·74
1970-71	72·96
1973-74*	77·90

*Provisional estimate.

7.6. Till the end of 1971, before the nationalization of the coal mines, the coal industry was organised into a number of mines mostly privately owned and very small in size. In January 1971, the number of mines in operation was over 800 and the size-wise classification was as follows :—

TABLE 7.5

Sizewise Distribution of Coal Mines (1971)

Size/Production per year* in tonnes	No.	Annual Production in million tonnes
1. Up to 6000	228	less than ½
2. between 6,000—12,000	47	less than ½
3. between 12,000—60,000	211	7
4. between 60,000—1,20,000	100	9
5. between 1,20,000—3,00,000	130	25
6. between 3,00,000—6,00,000	74	28
7. above 6,00,000	7	5

*As per the licensed or approved production capacity.

It may be noted that over 480 mines had a total production of only 8 million tonnes, indicating the smallness of operation of the majority of mines. After nationalization, the entire coal industry, except for 9 captive mines of the two private sector steel plants, (and some tiny coal mines in certain locations) has come under three public sector corporations. Bharat Coking Coal which took over 208 coking coal mines and 186 non-coking coal mines, has reorganised them into 86 units. Coal Mines Authority, which took

over 297 private mines and 44 mines of the National Coal Development Corporation is still in the process of reorganizing them. In its Eastern Division 215 mines have been reorganised into 86 units. The number of colliery units at present may be taken at about 376 against about 800 before nationalization.

7.7 The degree of mechanization in the different mines varies widely. There are mines which are still using primitive methods of mining where production is very labour-intensive; there are also mines which are highly mechanized.

7.8. The employment in the coal mining industry which has recorded* as 3.99 lakh persons in 1961 is reported to have declined to 3.66 lakh persons in 1971; but in the process of nationalization of the coal mines it was noticed that part of this decrease was due to misreporting of labour employed in the mines with a view to avoiding payment of the legal dues to the workers. There is, however, evidence that a large portion of the increase in productivity in the Sixties has come from increases in labour productivity. The output per mine shift* (OMS) has increased from 0.35 tonnes in 1951 to 0.48 tonne in 1961 to 0.67 tonne in 1971. Part of the increase in productivity is also due to increase in production in coal from open-cut mines instead of underground mines. The average output per mine shift in the open-cut mines is ground 1.3* tonnes though in completely mechanised mines like Jhingurda, it is as high as 6† tonnes; the output in underground mines is however around 0.5 tonnes.‡ The production† derived from opencast mines was 10.82 m. tonnes in 1961 which increased to 15.43 tonnes in 1972-73.

7.9. The inadequacy of rail transport affected coal consumers severely in the beginning of the Sixties resulting in the shift to the use of oil products by a number of industrial units, particularly in the western and southern regions. With the easy availability of furnace oil and its obvious advantage over coal in utilization, these industries continued with the use of furnace oil even after the rail transport situation improved in 1964-65. From 1964-65 onwards, the rail capacity was ahead of the coal demand and the Railways had to go, to the extent of suspending certain line capacity works (e.g., Singrauli-Katni link) and cancelling the orders for a large number of wagons. The best performance of the Railways in coal transport was in 1969-70 when they moved 71 million tonnes. The situation changed suddenly from 1970-71 and again an era of wagon shortage has started. In 1973-74, the Railways were able to move only about 61 million tonnes of coal. In terms of the average number of wagons loaded per day, the figures for 1969-70 and 1973-74 are 8191 and 7398 respectively. The year 1973-74 witnessed a large scale shortage in the availability of coal throughout the country inspite of the production recording the highest level so far reached, nearly 78 million tonnes. This fell short of the demand which has been assessed to be of the order of 85 to 90 million tonnes. The shortage was most actually felt by small industries, brick kilns, consumers of soft coke and other categories who get low priority in the allotment of wagons.

Coal demand

7.10. In our estimates of coal demand in 1978-79, 1983-84 and 1990-91, we have taken note of the anticipated levels of production of different major commodities in the industry sector and the possible changes in the technology of their production. We have also provided for the increasing efficiency of use of coal in the power sector and its progressive substitution as a feedstock for nitrogenous fertilizer production and as a fuel in the industry sector in replacement of oil. A fast rate of growth in the use of soft coke and low temperature carbonised coke as domestic fuels have also been provided for.

On these assumptions, our estimate of demand for coal for direct use and for power production will be as follows:—

TABLE 7.6

Demand for coal in 1978-79, 1983-84, 1990-91

(In million tonnes)

Coal use	1970-71	1978-79*	1983-84*	1990-91*
1. For direct use in enregy sector ..	51·4	85·0	124·0	198·0
2. For indirect use in energy sector ..	14·6	53·0	80·0	144·0
3. Total in energy sector	66·0	138·0	204·0	342·0
4. For non-energy use@	..	3·0	7·0	11·0
5. Total coal ..	66·0	141.0	211·0	353·0

*As per Case-II in Chapter III.

@Coal used in Sindri plant is accounted against coke production; coke oven gas is used for fertiliser production.

7.11. The rate of growth of coal production will be 12.6 per cent during the Fifth Plan, 8.4 per cent in the Sixth Plan and 7.6 per cent in the period upto 1990-91. The target rate of increase in coal production is somewhat high

(a) Monthly Coal Bulletin, January 1973 issued by the Director General of Mines Safety, Government of India.

*Monthly Coal Bulletin, January 1973 issued by the Director General of Mines Safety, Government of India.

†National Coal Development Corporation, Ranchi (Progress Report for April 1973).

‡Office of the Coal Controller.

during the Fifth Plan on account of the increasing demand for power production as well as from the steel industry. In physical quantities the average annual increase in production would be 11.2 m. tonnes per year during the Fifth Plan, 13.2 m. tonnes during the Sixth Plan and 19.7 m. tonnes during the period beyond the Sixth Plan upto 1990-91. Viewed against the average rate of increase of production of less than 2 tonnes per year during the Sixties, it is clear that the critical period in meeting the coal demand would be the Fifth Five Year Plan period when a steep increase in the rate of growth in coal production has to be achieved. The subsequent rates of growth visualized will prove more easy to accomplish once this hump is crossed.

Indigenous coal availability

7.12. In Chapter IV, a survey of the coal resources available in the country has been made. This indicates that upto 1990-91, the *gross resources of coal available in the country would be adequate to meet the requirements. The long-term perspective of coal supply is discussed in Chapter VI. While on global considerations, the entire coal demand could be met from the resources available within the country, there may be problems in meeting specific demand from the nearest source of supply. As indicated in Chapter V, it is not possible at this stage to forecast on a reliable basis the demand for coal in the different regions of the country in the coming years; but on the supply side, it is possible to estimate the physical levels of production of coal from the different coal fields in India based on geological and mining information available regarding the fields. Experts in the Coal Industry have agreed that the physical levels of maximum production from the different mines in the country may be as follows :—

TABLE 7.7

Possible levels of production of coal from different coalfields upto 1990-91

(in m. tonnes)

Coal field	1978-79	1983-84	1990-91
1. Makum/N.E. region ..	1	2	3
2. Bengal-Bihar			
(*a*) Jhari	26	36	50
(*b*) Mugma & Raniganj ..	33	45	60
(*c*) East Bokaro ..	7	12	13
(*d*) South Karanpura .. West Bokaro and Ramgarh	12	24 (coking 5)	30 (coking 7)
(*e*) North Karanpura (incl. Hutar & Daltongunj)		15	22
(*f*) Rajmahal		3	10
3. Singrauli (MP & UP) ..	7	15	24
4. Talcher (Orissa)	4	8	12
5. Sohagpur & Korea-Rewa ..	15	19	20
6. Korba-Hasdeo & Ib river ..	5	12	22
7. Pench-Kanhan-Tawa ..	7	7	8
8. Kamtee (Maharashtra) ..	2	5	7
9. Chanda-Wardha ..	4	6	10
10. Godavary Valley ..	12	16	21
	135	225	312

*Proved plus indicated plus inferred reserves.

7.13. These production levels are based on the informed judgment of experts in the geology and production of coal; these should be taken as a broad perspective based on information now available and may need corrections and adjustments as more information becomes available on further exploration and investigation. The Committee has therefore not tried to match the demand with the feasible production which as indicated above falls short of the required level in 1990-91 by about 41 m. tonnes.

7.14. It is relevant to note that the achievement of the levels of production in different coalfields, detailed investigation of deposits has efforts in exploration, detailed investigation of deposits and advance action for setting up mines and mechanisation of the mines. In many of the coalfields, detailed investigation of deposits has been neglected in the last few years and the lack of detailed knowledge about the characteristics of the deposits has proved to be a limiting factor of production. *The Committee recommends that detailed investigations should be aimed at proving sufficient mineable deposits for the requisite level of production related to the demand for coal estimated for* 1990-91. On broad calculations, it appears that even the level of production from different fields as suggested will lead to the Western and Northern regions being in deficit and to these regions coal will have to be transported during the period from Bengal-Bihar area. Bengal-Bihar coalfields are old coalfields having over 50 per cent reserves of the country including prime coking coal and good quality non-coking coal. Raniganj and Jharia coalfields produced about 52 m. tonnes out of a total of about 78 m. tonnes in 1973-74. In the period upto 1990-91 a little over half the coal requirement of the country will continue to be produced in these regions. Korea-Rewa in Central India, Pench-Kanhan in Madhya Pradesh, Chanda in Maharashtra and Singareni in Andhra Pradesh were developed as outlying coalfields to supply the requirements of the Western and the Southern regions. Assam, Bokaro and Karanpura coalfields were originally developed as minor coalfields to supply some specific requirements. It is during the Second Five Year Plan period that extensive development of mechanized open-cut mining was made in Karanpura and other outlying fields. During the Third Five Year Plan period, extensive new developments in Korba, Talcher, Tawa Valley, Umrer, Silewara, Korea-Rewa as also deep mining in Jharia coalfields were taken up. During the Fourth Five Year Plan, the establishment of the new mines in Singrauli coalfield provided a rational source of supply in the early years for meeting the needs of the Northern region. During the Fifth Five Year Plan, new mines will be added in all the coalfields. During the Sixth and Seventh Plan periods, it is possible that many old mines in Pench-Kanhan, Jharia and Raniganj will be exhausted of coal reserves

and many of the existing mines will have to go deeper in their workings. When mines are exploited at such great depths, sophisticated equipment is needed both for mining and for safety. Adequate equipment should be made available either by developing indigenous capacity for its manufacture or by import. Adequate replacement of mines will have to be planned for by early Sixth Plan and the new coalfields like Singrauli, Rajmahal, North Karanpura, Hasdeo-Arand etc. will increase in importance. *The Committee recommends that a careful perspective of coal production should be planned on the basis of the information available and suitable action for exploitation and mine planning taken in advance in the different coalfields. This perspective plan for the coal industry should be followed by preparing a shelf of project reports well in advance of each plan period. A Central Mine Planning and Design Institute has been set up at Ranchi. This institute will be developed with Polish Collaboration. It is desirable that this Institute does not confine its activities only to the preparation of project reports but participates in all activities connected with the formulation and implementation of the perspective plan for coal. This would include exploration and detailed investigation (in association with the Geological Survey of India and Mineral Exploration Corporation) of promising areas, assessment of their potential over a period of 20—25 years, suggestion of priorities for development and preliminary feasibility studies of the projects.* In this connection, the Committee would like to emphasise the importance of providing adequate power supply for the collieries and washeries. It has been reported that there are frequent interruptions and breakdowns of power supply in the coalfields areas resulting in the hampering of production and occasionally endangering the safety of the mine workers. *The Committee suggests that seps be aken urgently to eliminate this drawback and ensure adequate and uninterrupted power supply to collieries and washeries.*

Coking coal

Categorywise and Gradewise Coal Demand :

7.15. Coal can be classified into two broad categories, namely, coking coal which is required for the metallurigical industry and non-coking coal which includes all coal other than coking coal. It is difficult to describe in general the different qualities which make coal suitable for metallurgical purposes but the most important is its capacity to be converted to coke measured by its coking index. Coking coal is classified into three different types, namely, prime coking coal, medium coking coal and semi-coking or blendable coal. Of these, prime coking coal is the most important as it is a necessity for the production of steel using the conventional steel production processes. Medium coking and semi-coking coals are useful for the production of coke when they are used along with the prime coal in the coke ovens. The pattern of utilisation of different categories of coking coal would depend on the anticipated level of production of steel, the relative availability of different categories of coking coal and the range of technical blending possibilities. The estimate of coking coal demand is as follows:—

TABLE 7.8

Coking coal demand 1978-79, 1983-84 *and* 1990-91

		(Million tonnes)		
		1978-79	1983-84	1990-91
Prime coking coal	..	17·6	28·0	45·0
Medium coking coal	..	17·0	22·0	39·0
Blendable coal	..	1·7	3·0	6·0
Total	..	36·3	53·0	90·0

Notes :

(i) Estimates correspond to the following anticipated hol-metal production in the steel industry:

	M. tonnes
1978-79	14·3
1983-84	22·3
1990-91	36·0

(ii) Blends and washed coal requirements are assumed for all merchant ovens.

(iii) Progressively prime coking coal of higher ash content is assumed to be used.

The production of steel by electrical arc furnace is not taken note of and any production from this source will be additional to the levels of steel production assumed in these calculations. The coal requirements for the manufacture of hard coke from merchant coke ovens have been taken note of.

Resource availability and conservation of coking coal

7.16. In Chapter IV, we have indicated that the total availability of coking coal proved, indicated and inferred categories will be about 20,154 m. tonnes. The proved categories add upto only about 9,000 m. tonnes. Only above 50 per cent of the coal available in the ground can be extracted using mining techniques now in practice. As most of the coking coal is of high ash content, it requires to be washed before it can be used for coking. In washing about 45 per cent of the coal is lost as middlings and rejects and only 55 per cent is obtained as washed coal suitable for feeding into coke ovens. It should, however, be noted that new coal preparation techniques and development in steel technology may improve these ratios. But in our calculations no improvements have been assumed

as no definite indications are available in this direction as of today. A systematic analysis of the prime, medium and blendable coal reserves and their likely demand over time indicates that *prime coking coal may get exhausted in about 40 years' time. The medium coking coal may last for some more years. However, as prime coking coal is essential for metallurgical purposes, it is necessary to take all efforts from now on for the conservation of prime coking coal, in particular, and of coking coal, in general.* If the ratio of prime coking coal used in the steel industry is not reduced to technically feasible limits, the exhaustion of our prime coking coal reserves will be speeded up further (as the calculations of this Committee is based on such reduction being achieved gradually).

7.17. Research conducted by the Central Fuel Research Institute has established the maximum quantities of medium coking coal and blendable coal that could be added to prime coking coal in the coke ovens. Based on these researches as well as taking into account the facilities for blending at the steel plants, the CFRI had estimated the optimal blend possible by 1978-79 as follows :—

Ratio of the blend in percentages

Prime coking coal	50
Medium coking coal	43
Blendable coal	7
Total	100

Individual plants might be taking the different varieties in proportions which are somewhat different but the steel industry as a whole is expected to conform to the above blend. Inspite of the great urgency for conserving the prime coking coal resources, the actual degree of utilization has exceeded what is technically desirable. The following Table gives the blend of coking coal allocated to the steel plants during March, 1973 :—

TABLE 7.9

Share of prime, medium and blendable coking coal used in the steel industry

Coal allocations to plants	Prime	Medium	Blendable
	(Percentages)		
Bhilai	55·8	38·4	5·8
Rourkela	42·9	45·2	11·9
Durgapur	60·6	18·1	21·3
TISCO	58·6	31·0	10·4
IISCO	75·7	16·9	7·4
Bokaro	57·1	42·9	..
Average for all plants	57·5	32·8	9·7

The reasons for this appear to be the easier availability of prime coking coal and the lack of selective crushing facilities at the steel plants. *Production of the different grades of coking coal in future will need to be planned in accordance with the proportion in which they are needed in the steel plants and adequate crushing and preparation facilitits have to be installed in all steel plants. The planning of metallurgical coal mines and the construction of steel plants will have to be carefully synchronised. As steel and coking coal production have been placed under single authority, such synchronised planning should be easy.*

7.18. While all methods of conserving of coal and a greater degree of conserving of coking coal could be taken up in the long run, the Steel industry in India should also plan for the production of steel when coking coal becomes scarce. There are four technical possibilities of conserving coking coal:—

(i) Use of small quantities of low sulphur heavy stock (LSHS) and fuel oil of certain quality partially in place of coke.

(ii) Pre-reduction of iron ore.

(iii) Development of the technology for the use of beneficiated non-coking coal (like formed coke) for steel making.

(iv) Injection of coal dust/producer gas.

The use of LSHS can be adopted even in the short run while the others are distant possibilities. *It is necessary that research and development activities in this regard are speeded up from now on.*

Stowing with crushed material

7.19. One method of increasing the availability of coking coal is the use of stowing. A large part of Indian coal mining which involves mining of thick seams underground calls for stowing in Jharia, Bokaro and Karanpur coalfields. There is extreme shortage of sand needed for stowing and this has stood in the way of higher percentage of extraction. *It is considered necessary that arrangements for stowing crushed stone locally available be made so as to permit mining of underground coal from thick coal seams. This will help conservation of underground coking coal and high grade non-coking coal in Jharia. A long-term plan for meeting the stowing material requirements of the coal industry should be drawn up and implemented.*

Open-cast mining in Jharia coalfields

7.20. It is realised that with the limitations of coking coal reserves in the country, especially the prime coking coal variety, there would be constraints on planning for large scale steel production beyond say 30 m. tonnes of hot metal. One of the ways to increase extraction percentage of coal is to win the coal by open-cast mining

with, say, 90 per cent coal recovery as against the underground mining, which gives an average recovery of only 50 per cent of coal reserves. From the aspect of stowing of coking coal and with a view to prolonging the life of the reserves it would be worthwhile to take up studies for examining the possibility of large scale mechanised open-cast mining in Jharia coalfield with much higher overburden to coal ratio. It is recognised that there are technical problems as some of the areas are already honeycombed by underground first workings and some areas are subject to fire or seams have already caved in, apart from the problems of surplus workers and built-up areas. *This matter needs to be studied in depth, in the context of the need for higher level of hot metal production and maximising the indigenous availability of metallurgical coal.*

Washeries

7.21. As already indicated, the reserves of coking coal are poor in quality and require beneficiation before they can be used for metallurgical purposes. Normally, the steel plants prefer coking coal with ash content of less than 17 per cent. Most of the coking coal in India has ash content above this limit of acceptability and, therefore, requires to be washed. There are 14 washeries in the country at present, 10 of which produce three products, namely, washed coal, middlings and rejects and the rest of which produce only two products viz. washed coal and sinks. The Energy Survey Committee recommended that it will be in the national interest to have only two product washeries in future. But experience has shown that the quality of sinks obtained from two product washeries is unsuitable for power plants as they contain a lot of abrasive material besides ash which impair the efficient functioning of the power plant. A later technical Committee* has recommended that here should only be three product washeries in future and that steps should be taken to convert the two product washeries into three product washeries. The discussions with the consumers of the middlings and the coking coal producers lead this Committee to the view that *in future there should be only three product washeries.*

7.22. A study of the availability of different grades of coal for the metallurgical industry indicates that there will be need for washing blendable coal also from the years after 1978-79. So there would be need for building up washeries to the extent of about 2 m. tonnes capacity each year during the next decade and probably around 3 m. tonnes each year in the period beyond the Sixth Plan. The capital cost of washeries and the operating expenditure of washing have been increasing. *It is necessary to undertake research for evolving suitable designs for washeries which are best suited for washing Indian coal and which would reduce the costs of washing coal.*

Qualitywise demand and supply of non-coking coal

7.23. Non-coking coal is classified into different grades on the basis of the ash and moisture content. Consequent on the classification based on ash and moisture content, the calorific value of different grades also changes. Within each grade, there is a slight change in the calorific value based on whether the coal is of high moisture or of low moisture variety. Broadly, the classification is as follows:—

Grade	Ash content	Calorific value Kilo-cal/kg.
USA ..	15% to 17%	6360 to 6480
Grade I	17% to 20%	5960 to 6360
Grade II ..	20% to 24%	5560 to 5860
Grade III A & B	24% to 35%	5000 to 6060
Ungraded ..	35% to 40%	Below 5000

NOTES—1. Singareni and Assam coals are not graded Broadly they would correspond to Grade II and Selected 'A' Grade respectively on the basis of ash content.

2. The above figures relate to low moisture coal. The C. V of high moisture coals ares slightly lower in each grade.

7.24. During the period when there was distribution control for coal, the quality of coal to be allotted to different consumers was determined with reference to the technical requirements (adjustments were always made on considerations of availability and historical usages). After the removal of the control over coal distribution, the use of different grades of coal is determined by consumer preference. Due to inadequate differentials between the prices of superior coals and inferior grade coals, there is always pressure on demand for superior grade coals. After nationalisation, quality-wise distribution is being attempted consistent with the requirements of the consumers and the availability of coal in the various coalfields. It is difficult to project the demand for different grades of coal as most of the industries can use any grade of coal provided of the cement units and about 50 per cent of the the furnaces are designed specifically to use that grade of coal. On broad calculations, it can be stated that the requirements of railways, most industries will have to be supplied in the form of superior grade coals, while the rest of the industry, power houses, domestic and other requirements could be supplied inferior grade coals.

*The Committee Coal Washeries headed by Shri K. S. R. Chari, 1972.

7.25. Reserves of selected grades of non-coking coal are estimated at about 400 million tonnes only. This includes 136 m. tonnes of Assam coal which has high sulphur content and is also located far away from the points of possible industrial consumption. The utilizable quantity of selected grade coal appears to be severely limited. Grade I and Grade II coals are relatively more plentiful, the total proved reserves being about 3600 m. tonnes. Of this about 2200 m. tonnes are in the Bengal-Bihar coalfields. As most of the industrial consumers prefer to use this grade of coal, increased use of coal for industries may call for production increases in the Bengal-Bihar area and transportation to other regions. The remaining coal is of the lower categories and is available in all the other coalfields in the country. The largest deposit of low grade coal appears to be in Singrauli coalfield. The increasing use of coal for industries will have to be based either on the increased production of superior grades lying in Bengal-Bihar or by the use of washed coal or by washing inferior coal available in the outlying coalfields.

7.26. *Washing of non-coking coal is a costly process and leads to large increases in the cost of washed coal. Other methods of improving the quality of coal supplied to consumers, like simple high specific gravity washing of coal, handpicking of better grade coal and proper sizing of coal by screening, etc., should therefore be explored and the choice of 'beneficiation' decided with due regard to consumer requirements, available grades of coal, the scale of the required operations etc.* Most of the consumers require a specified grade of coal and not necessarily a superior grade of coal. Among the numerous characteristics of coal, each consumer class considers certain specifications as critical to its needs (like ash fusion temperature in respect of coal power plants). Changes in the quality of coal, especially variations in the critical specifications, lower the efficiency of fuel utilisation and may even lead to damaging the coal using equipment. *The coal industry should therefore accept the responsibility to supply on a long term basis, an agreed grade of coal, by changing if necessary the source of coal supply from time to time or by blending different grades of coal to make up the required grades.* Alternatively the washeries should be set up to beneficiate the coal and sustain the specified quality. *Power stations will also have to take care in designing the boilers based on correct appreciation of coal characteristics.*

Sectorwise consumption

7.27. In Chapter II, an analysis of the past trends in the sectorwise consumption of coal was made, taking into account only the coal used directly; coal used for power generation was excluded in the analysis, as energy used as electricity (including electricity generated from coal) was separately examined in that Chapter. For evolving a policy for the coal sector, it is of interest to take the total coal consumption including consumption for power generation and to analyse the sectorwise composition of consumption. The Table below sets out the consumption in different sectors in 1970-71 and the anticipated consumption as per estimates set out in Chapter III.

TABLE 7.10

Sectorwise Consumption of Coal 1970-71 to 1990-91*

(In m. tonnes)

Sector	1970-71	1978-79	1983-84	1990-91
1. Mining and Manufacturing . . .	31·9	61	88	152
2. Transport . .	15·1	13	11	10
3. Domestic . .	4·1	10	23	33
4. Energy Sector (Power Generation) . .	14·6	53	80	144
5. Others	0·3	1	2	3
Total . .	66·0	138	204	342

NOTES—*Based on case II estimates.

(*i*) Quantities in the table exclude colliery consumption.

(*ii*) Coal used in non-energy sector *i.e.*, as fertiliser feed-stock is excluded from the above.

(*iii*) There is no coal use in agriculture sector.

(*iv*) Row 1 excludes quantities of middlings generated in steel sector but used in power sector.

(*v*) Row 4 includes coal consumed as middlings for power generation.

(*vi*) Row 5 includes export.

7.28. The percentage shares of different sectors in total coal consumption show interesting trends as set out in Table below:

TABLE 7.11

Sectorwise Share of Coal Consumption 1970-71 to 1990-91

(In percentage)

Sector	1970-71	1978-79	1983-84	1990-91
1. Mining and manufacturing	48·3	44·2	43·1	44·4
2. Transport. ..	22·9	9·4	5·4	2·9
3. Domestic ..	6·2	7·3	11·3	9·7
4. Energy Sector (Power generation) ..	22·1	38·4	39·2	42·1
5. Others	0·5	0·7	1·0	0·9
Total ..	100·0	100.00	100.00	100.0

The share of total coal used in the mining and manufacturing sectors will continue to be around 45 per cent throughout the next two decades. The share of the energy sector will rise very rapidly in the next five years and at a slower rate from then on. The share of the transport sector in the total coal will taper off very rapidly. The factors which influence these trends deserve careful consideration.

Use of coal in power sector

7.29. The electrical energy anticipated to be derived from coal-based thermal power stations and the likely requirements of coal for generating that power are set out in Table below:

TABLE 7.12

Coal Requirements of the Power Sector

Year	Estimated Power generation from coal based power plants (b. kWh)	Total coal demand (m. tonnes)	Of (3) the likely supply of	
			Coal (m.) tonnes)	Middlings (m. tonnes)
1	2	3	4	5
& 1972-73	35	19·5	17·5	2
1978-79	74	53	48	5
1983-84	115	80	68	12
1990-91	224	144	125	21

*Provisional.

The demand for coal for power generation may almost double in the next five years and may increase by a lower factor in the VI Plan. The share of middlings in the total coal consumed in the power sector may increase from 10 per cent in 1978-79 to 15 per cent by 1983-84 and continue at a little over this level thereafter.

7.30. Power sector will be the most important coal using sector in the economy in the coming years. The new developments in the power generation technology like large unit sizes of generating plants and the setting up of thermal power stations with a battery of generating plants at one site will call for the movement of large quantities of coal to a few consumption points. As an illustration, a power plant with 1000 MW capacity may require 3 million tonnes of coal per year; in other words, the power station will have to receive nearly 10,000 tonnes of coal per day. Such large movements to one destination will require detailed planning of the supply, years ahead of the requirements. The arrangements for supply of coal to large power stations should not only ensure the synchronised development of the coal mine and the power plant but also the setting up efficient handling systems at the mine site and the power station. *Coal Fields Linkage Committee, recently established by the Government to examine and approve the specific coal supply points for each major consumer, should consider the loading arrangements at each end and give suitable suggestions. The Electricity Boards which operate the power stations should give greater attention to the problems of coal handling and storage; optimal stock levels for each plant should be worked out with reference to the source of coal supply, its distance from the power plant, reliability of the rail-link, the seasonal variations in these factors, etc.* In recent years the failure of the monsoon and the consequential reduction in the supply of energy from hydel system necessitated greater utilisation of the thermal system. At this stage the arrangements for coal supply proved inadequate which led to serious difficulties. In the coming years, when power sector will consume a very large share of total coal, even small seasonal variations in the demand of coal will affect the coal supply to other sectors; coal industry cannot meet any sudden increases in coal demand without seriously curtailing supplies to other sectors. *This difficulty may be mitigated to some extent by building up adequate stocks in the major power stations to meet the increased demands in the drought years.* As indicated in Chapter IX, the preparation of coal will increase the efficiency of fuel usage in power stations by about 10 per cent. It is also important to note that it may not be possible to supply large quantities like 3 million tonnes annually for a number of years from the same mines without variation in quality. *In the major power plants it would be useful to have arrangements for sizing, blending and preparation of coal before it is fed into the boilers so that the possible changes in quality of coal received, are taken care of.*

7.31. Qualitywise, thermal power stations would have to consume as far as possible high ash coal or washery middlings. The power plants also have to use more elaborate material handling system, ash disposal system etc. It is, therefore, necessary that power plants should be given adequate price incentives to use the low grade coal. This is of particular significance in the pricing of "middling". The power projects based on the use of middlings are dependent on the level of utilisation of the washery for adequate middling supply and the power plants have to use this middling, even though relatively superior grade of coal may be available in the area. *It is necessary therefore to have a suitable pricing policy for the use of middlings for power generation, if such use is to increase as estimated in the Report to about 21 million tonnes by* 1990-91.

7.32. The supply of middlings to the power stations depends on the level of utilisation of the washeries which, in turn, would depend on the demand for washed coal from the steel industries. The estimates of the availability of middlings have been made with reference to certain assumed levels of steel production. If there is any shortfall in steel production, there is bound to be reduction in the availability of middlings. It is, therefore, important that the construction

of power plants based on middlings and steel plants is synchronised. Even if the plants come into operation simultaneously, there may be fluctuations in the demand for coking coal. It may, therefore, be desirable to keep certain alternative sources of supply of inferior grade coals in the nearest possible source to serve as a contingent source of supply.

7.33. A region-wise analysis of the demand for coal for power generation indicates that the southern and the western regions will be short of coal supplies from their regions. It is difficult to forecast the region-wise requirements of coal for power generation at different points of time in future. Broadly speaking, the northern region will be dependent heavily on the hydel power stations supported by a system of thermal power stations. The best source of supply of coal for power stations to north India would be Singrauli coalfields, the large scale development of which is planned; but the development of Singrauli coalfields is not likely to keep pace with the demand from power stations in the northern region. There is need, therefore, to increase the transport capacity from the Karanpura coalfields to north India. For the western region, the coalfields of Tawa Valley, Pench-Kanhan, Korea-Rewa, Korba, Chanda, Kamptee and Umrer will be the convenient sources of supply. Of these, a large deposit with possibilities of open-cut mining is available in Korba. In addition, the coalfields of Hasdeo-Arand Raigarh etc. in Madhya Pradesh will have to be developed to meet the requirements of the western region power stations in the Sixth and Seventh Plan periods. Another possibility is the movement of coal by ships along the coast from the Bengal-Bihar region to power stations to be located at port sites in the western region. Careful planning for such power stations will have to be drawn up in advance of the Sixth Plan so that optimal transport arrangements could be planned. The southern region has Singareni coalfields and lignite deposits at Neyveli to provide the major fuel requirements for power generation. Only one-fourth of the 2000 m. tonnes of gross reserves of Singareni have been proved. There is need for proving more reserve by taking up detailed investigations of the deposits, as early as possible in the Fifth Plan so as to provide the basis for planning power plants for meeting the requirements in the Sixth Plan and the Seventh Plan. A number of examinations of the power requirements of the southern region lead us to the conclusion that development of lignite deposits in Neyveli should be expedited to provide the fuel for thermal stations in the deep south. It may be noted that the southern region is fast exhausting the easy resources of hydel power and has to go in for large hydel power stations with long gestations or a few micro hydel power stations with minor contribution to energy requirements. There is, therefore, need to plan for increased production of Singareni coal and Neyveli Lignite. Even then, considering the requirements for other uses also, there is a case for movement of coal from Bengal-Bihar to southern region. It may be necessary to examine the feasibility of setting up power plants in southern region based on coal from Bengal. Taking an overall view of power requirements and coal supply feasibility, *it is clear that meaningful plans for thermal power generation have to be drawn up from now on, in a coordinated manner with the plans for coal production in this region. As the requirements of power sector are fairly well established, the detailed investigation for coal mines to supply the requirements of the power stations should be taken on hand immediately*

Coal for mining and manufacturing sector

7.34. The requirements of steel industry have already been discussed in paragraphs relating to coking coal. The important industries using non-coking coal are cement, textiles, paper, sugar, chemicals, jute, etc. The fertilizer industry has so far been using coal for steam raising only. But during the Fifth Plan period, three fertilizer plants at Korba, Talcher and Ramagundam will require coal as feedstock. In the estimate of demand, we have taken note of the increase in demand from the major industries including the demand for coal as feedstock for nitrogenous fertilizer. The forecast. of demand has made some marginal adjustments for the shifts in the technology of manufacture of cement and some improvements in efficiency in the other industries. Most of these industries can use inferior grades of coal; but industries like glass and certain chemical industries and some of the cement units will require superior grades of coal as the temperature to be raised in these units may be very high. It is difficult to estimate region-wise demand for coal for industrial uses. Individual industries, except the cement plants and the fertilizers plants, will require relatively small quantities of coal as compared to the power plants. There is another category of industrial consumption of coal, namely, the brick-kiln industry which will require coal for a large number of kilns all over the country, and each of these consumers will require a small quantity. It is in this context that the planning of coal dumps assumes importance. The dumps will enable the individual industries to operate with lower inventory of coal without endangering the security of supplies. The major regions of coal demand for industrial use are fairly well known. The cities of Bombay, Calcutta, Madras, Ahmedabad, Patiala/Ludhiana, Hyderabad, Bangalore, Kanpur are examples of the industrial towns where there will be an increasing demand for coal for industrial use. *If coal requirements for the industrial consumers, which will increase over time, is to be met satisfactorily, coal dump will have to be set up in all the major industrial regions.*

7.35. It may be noted that movement to the coal dumps should also be supplemented by the

movement directly to large consumers which can be planned without reducing the efficiency of coal movement by rail. *There would be a five-fold increase in the next two decades in the requirement of coal for mining and manufacturing sectors and this would call for detailed planning from now on and the locational policies regarding industries should be consistent with the plants for the production and movement of coal.*

Coal for transport sector

7.36. Historically, railways were the largest single consumer of coal, but with the increasing intensity of traffic on the railway system, steam locomotives have lost their advantage to diesel and electric locomotives which can run faster and can haul greater loads per train. The studies indicate that except on rail routes where the annual traffic is less than 5 m. tonnes, it would be uneconomic to use the steam locos. It is, therefore, unavoidable that the use of coal in the railway system would be slowly reduced. (Optimisation of the traction with different modes of traction is discussed separately later). The steam locomotive fleet of the Indian Railways in 1990-91 is expected to consist of about 5500 locos i.e. about 60 per cent of the existing number. The coal demand at that time would be about 10 m. tonnes. As the railway requirements of coal will get reduced from now on, till 1990-91, there is no need to draw up special plans for ensuring the supply of coal to the railways.

7.37. Some quantities of coal are used for steamer services in the Ganga-Brahmaputra water-based system. With the increased trade and commerce between India and Bangladesh, this traffic is likely to grow. But the quantities of coal will continue to be relatively small and, as this region is very near the coalfields, no special plans need to be drawn up for this purpose.

Coal for domestic sector

7.38. The domestic sector will require coal in all its raw forms to be processed as a smokeless solid fuel or gas. The demand for soft coke is kept under severe constraints by the lack of availability of soft coke at the consumer end. Since the pressure on forest fields and kerosene has to be reduced, the supply of coal to the domestic sector has to be increased. As calculated in this Report, the supply of coal to the domestic sector will be more than double in the Fifth and the Sixth Plan periods, and from then on, will increase at a somewhat lower rate.

7.39. Most of the processes of conversion of coal to smokeless solid fuel with relatively lower investment costs, are based on the use of coking coal, though of lower grades. Non-coking coal can also be processed by adopting the low temperature carbonization process which will require higher level of investment per unit of soft coke tothe be produced. The Committee had recommended in the report on the Fuel Policy for the Seventies that action should be taken to set up two low temperature carbonization plants and it is gratifying to note that action is being taken to set up two plants—one at Singareni and the other near Calcutta. In the context of the current oil situation, more units based on the LTC process may have to be set up. But throughout the period upto 1990-91, a major portion of the domestic coal requirements will have to be met by using the low grade coking coal which is available in the Bengal-Bihar region. This will lead to an increase in the demand for railway movement of domestic coal from Bengal-Bihar to various parts of the country since the success of all efforts to supply soft coke to the domestic sector will depend on the capability of the railway system to move coal from Bengal-Bihar. *The Committee would therefore recommend a careful plan to be drawn up for increased movement of soft coke from the Bengal-Bihar region to the urban centres in the country.*

Exports

7.40. Indian coal with its high ash content has a handicap in competing with coal from other coal exporting countries. The countries which are geographically near to India and are poor in energy resources, would be dependent on exported coal from India. However, the increasing pollution consciousness in different countries may increase the demand and the fact for Indian coal which has a very low content of sulphur; this may, in course of time, help in developing an export market for Indian coal. *We have estimated a somewhat modest export possibility of only 3 m. tonnes by 1990-91. This should be taken as a lower limit and separate plans for opening up export-based coal mines near the ports of Haldia and Paradeep may be drawn up; and possibilities of exporting this coal to Bangladesh and Burma and countries in the Pacific region will have to be separately considered without affecting domestic requirements.*

General problems of the coal industry

7.41. The coal industry as a whole has certain general problems which require very careful examination. These are—

(1) Problems relating to increasing productivity in the coal mines;

(2) Developing the transport capacity for coal movement;

(3) Beneficiation of coal to gas; and

(4) Equipment supplies for coal production.

Productivity

7.42. Productivity in the mines is normally measured in terms of "output per manshift" (OMS). The OMS in mines will vary throughout country with the extent of mechanization

adopted in India. In the early days of the coal industry in India, the mines were mostly non-mechanized and underground where production was based on primitive methods. The productivity in the mines was very low. But with the increasing mechanization in the mines, there has been steady increase in the OMS. The new mines which are opened up as Open-cast mines are based on the use of sophisticated machines like draglines, excavators, shovels and dumpers which give high productivity. In the new mines which are proposed to be opened, the output per manshift is around 0.8 tonnes per manshift in underground mines and about 4.5 tonnes in open-cast. The steady increase in the OMS of underground mines and open-cast mines and the total coal industry can be seen from the Table below:—

TABLE 7.13

Trend of output per manshift in coal mines

Year	O.M.S. of all persons in			
	Below ground	Open cast	Below ground and opencast	All in the mines
1951	0·58	0·54	0·57	0·35
1956	0·61	0·52	0·60	0·39
1961	0·66	0·64	0·65	0·46
1966	0·76	0·99	0·79	0·56
1971	—	—	0·95	0·67
1972	—	—	0·94	0·66

SOURCE—Statistics of Mines in India (for years upto 1966) and Monthly Coal Bulletin for 1971 and 1972, both published by Director General of Mines Safety.

It is noteworthy that inspite of the low productivity of around 0.6 tonnes per man shift, the wage cost of Indian coal is low and this makes the coal produced in India at the pit-mouth among the cheapest in the world. A discussion on the productivity and wage cost and the principles of production cost may be seen in Chapter XI. It is of the utmost importance that if the coal production in the country is to go up at the rapid rate envisaged in this report productivity in the coal mining industry must increase. It will not be meaningful to compare the productivity in India as a whole with the productivity of the coal industry in other countries when the mixture of technology used in coal production in our country is different from that of the other countries. But it would be valid to compare the production in specific mines proposed for opening up now with the productivity in similar mines in other countries which also used the same kind of equipment. An analysis of the new coal mining proposals indicates that the anticipated output per man shift in these compares favourably with that of the mines of a similar kind elsewhere; but an expost facto analysis of the mines which have been opened up during the Third and Fourth Plan periods shows that in very few mines the OMS has come up to the levels anticipated in the project reports. The reason for this is poor utilization of machines. While the labour force engaged in the mine is often in excess of the anticipated labour force, the machine utilization is very low compared to the projections made at the time of approving the mine proposals. The following Table sets out the expected and actual utilization of coal mining equipment in a major coal producing company.

TABLE 7.14

Expected and actual utilization of certain items of coal mining machinery in a major coal producing company.

Item of Equipment	Expected utilization (As percentage of shift hours)	Actual utilization 1971
A. *Open-cast Equipment*		
1. Shovels	60·3	34·4
2. Draglines	77·2	41·2
3. Dumpers	38·7	18·8
4. Dozers	41·2	21·8
5. Coal haulers	52·6	15·8
6. Drills	60·0	20·6
7. Overall weighted average	44·5	21·4
B. *Underground Equipment (face machinery)*		Percentage of total* number operation
1. Shuttle cars		71
2. Loaders		71
3. Coal cutting machines		86

*Expected productivity of these machines and the actual realization are not available.

7.43. Almost all the mines proposed for deriving additional production are mechanised mines. The production per man or production per machine in these mines can be realised as per the anticipation only if the machines are properly maintained and used and the labour is adequately trained in the use and maintenance of these machines. The mechanization of mines will have to be accompanied by training of the mining labour to use these machines. In the past, part of the labour used in mines, especially the privately owned mines, were contract labour who were not given the benefits which were legally due to coal mine workers. With the nationalization of the mines, all the workers will receive their legal dues. Moreover, lowering of producti-

vity will lead to huge losses to the coal industry which could be made up only by increasing the cost of coal to the consumer. *The Committe would therefore like to emphasise the importance of increasing productivity in the coal industry and would recommend that proper steps should immediately be initiated for the optimal use and maintenance of machines and for training coal mine workers in the use and maintenance of the equipment.*

Coal transport

7.44. Coal can be transported by railways, roadways, water routes, inland and coastal pipelines and rope ways. The selection of the specific mode of transport for coal will depend on the characteristics of the consuming industry, its distance from the supplying coal mine, the characteristics of the terrain between the point of supply and the point of consumption and the relative cost of the different modes of transport as paid by the consumer. In India so far, the coal production has been from numerous coal mines each producing small quantities; and the consumers, except the steel industry, have been relatively small consumers. The emergence of large power stating fertilizer factories and cement factories and the possible organization of coal dumps would increase the demand at specific points to quantities over a million tonnes. Similarly, after the nationalization of the industry, a number of coal mines are being combined to form large production units. This would call for changes in the modes of procedure and transport so far practised for moving coal in India.

7.45. The studies made by the Committee indicate that the railways constitute the most economic way of moving coal for most of the consuming classes and consumer locations in India. Coal transport in this country has been dependent on the railways for the carriage of about 85 per cent of the total despatches and will continue to be dependent on it for a major percentage in the future. This would entail a gigantic task for the railways which would be called upon by 1990-91 to move about four times the quantity of coal now transported. The siting of super-thermal power stations in the coalfields and the development of alternative means of transport like coastal shipping, inland waterways etc. are designed to lessen the strain on the railways. But the quantity of coal that could be used at the coalfield or moved by means other than rail will always remain small. *We reiterate that adequate attention should be paid to rail transport planning in regard to development of additional line capacity, yard capacity and signalling and communication which would facilitate speedier turn-over of wagons as well as augmentation of wagon fleet.* This would require substantial investments in the next two plan periods as the lead time required is considerable. The collieries have also an important role to play by maximising the movement of coal in block rakes moving from single loading points to single destinations and mechanisation of loading and unloading in all large output and consumption centres, modifying siding layouts to facilitate quick loading and speeding.

7.46. Planning for coal movement cannot be done in the light of broad directions of movement. Recent experience shows that even if the railway track capacity is adequate in certain directions, the limitations on the railway track capacity from the mine to the main rail load centres and the capacities from the main track to the consumer point have made it difficult to increase the quantity of coal that is to be moved by the railways. Detailed plans for transporting the required quantities from the pit-mouth to the consuming centres have to be formulated. Such plan should also give adequate attention to the optimal loading and unloading at the two ends. As indicated, since more than 50 per cent of the coal will have to be produced in the Bengal-Bihar area and as inter-regional movement will be required from the eastern region to all the other three regions of the country, the success in achieving the required coal movement by railways will depend largely on increasing the facilities for loading and transportation in the Bengal-Bihar area and for moving coal across well known bottlenecks in the railway system like Mughalsarai, Waltair, the Section over the Western ghats, etc. *The Committee would recommended that serious consideration should be given to the problems of coal movement in the Bengal-Bihar area and for removal of the factors which is not the capacity for Bengal/Bihar and movement in specific sections towards northern, western and the southern regions.*

7.47. The Committee examined in detail the possibility of using alternative modes of transport, besides railways, and in the light of techno-economic analysis, would rank the following modes in the order of their importance :—

1. Coastal shipping.
2. Roadways.
3. Ropeways.
4. Inland water; and
5. Slurry Pipelines.

Coastal shipping

7.48. The cost studies of moving of coal by coastal shipping from Bengal-Bihar to the southern and western ports indicate that under certain conditions, it can be as economical as movement by railways inspite of the fact that in all cases of coal movement by sea, coal has to be first taken by rail from coal mines to the ports in the eastern coast, namely, Calcutta/Haldia. Inspite of the fact that Indian coastal line is triangular in shape and the bigger ships have to go around the island of Ceylon which makes the distances from places from the east

coast to west coast much longer than the distance overland, rail-cum-sea route can be as economical as rail. Currently, the costs of carrying coal by rail-cum-sea route from Bengal-Bihar to Madras or to Bombay or Kandla are higher than the costs of carrying it by the all rail route due to the small size of ships used and the delays at Calcutta port for loading and at the receiving port for unloading. The total cost of transport by sea falls into three elements (i) ships' internal cost resulting directly from operations of the ship while at sea and while at the ports for collecting or unloading coal; (ii) port costs and (iii) the cargo costs which relate to loading and unloading of the cargo. Of these the internal costs while the ship is at the port has the largest weight at present. When the ship's loading and unloading time is reduced from 9 days at Calcutta and 8 days at Madras to two days at Calcutta and to 3 days at Madras the cost of carrying coal gets reduced by one-third. The completion of the Haldia port for coal handling facilities is expected to reduce the loading time at the eastern ports to about 2 days. Studies were made assuming the loading time at Haldia port as 3 days and unloading time at Bombay or Madras as 2. These indicated that costs of carrying coal by rail-cum-sea will compare favourably with the costs of carrying coal by all rail route. Taking note of these factors, the Fifth Five Year Plan envisages an increase in the movement of coal by coastal ships by 5 m. tonnes by 1978-79. There are possibilities of increasing this in the years beyond 1978-79. The quantities to be moved by sea would depend on the point at which the demand develops and the capacity of the rail system. But it is reasonable to anticipate that *there will be need for increasing the quantities of coal to be moved by sea over the entire period upto 1990-91. This would call for developing unloading facilities at specific points in the southern and western coasts where power stations or other coal consuming industries or coal dumps might be set up.*

Roads

7.49. Road movement of coal has been increasing in the last few years as a result of the shortfall in the planned movement of coal by rail. But cost studies indicate that for short leads for consumers whose specific demand may be small, the movement of coal by road will be economical compared to the movement by rail. The increasing demand for soft coke anticipated in the report will also increase the use of roadways for moving coal. *The setting up of coal dumps in major industrial areas will call for co-ordinated planning for movement of coal from the dumps to the consumer points by road alongwith the plans for moving coal from the mines to the dumps.*

Ropeways

7.50. Ropeway transport of coal is used at present where the conditions are favourable such as from a colliery to a nearby washery or power house. It will continue to have this limited utility in such areas especially where the terrain is unsuitable for other means of transport. Ropeway transport cannot have large scale application as the cost of transport is generally higher than that by rail.

Coal Slurry pipeline

7.51. The conversion of solid fuel or coal into slurry and its transportation hydraulically through pipeline is one of the possible alternate means of transporting coal so as to provide some relief to the overburdened railways. This mode of transport is best suited for the thermal power stations and some specific bulk consumers whose need for fuel is fairly large and constant.

The advantages in the transportation of coal in slurry form through pipeline are as follows :—

(i) Pipeline can be laid through mountains, deserts, rivers etc.

(ii) Fewer personnel required for erection, operation and maintenance.

(iii) As moving machines are located in pumping and boosting stations, the system is reliable and safe.

(iv) Loss of coal during transit is eliminated and the dust problem is minimised. The deterioration during transit is also prevented.

(v) Railway sidings, coal dumping and coal storage are eliminated.

(vi) In mining industry, it has facilitated adoption of hydraulic mining and transport which has reduced accident rates and dust hazards.

(vii) Hydraulic transportation is possible in all weather conditions; and

(viii) Capital and operating costs for power plants designed to handle pipeline coal are less.

A good deal of research on hydraulic transportation of coal has been done in different countries of the world. In India, the first study of this mode of transport was made by the World Bank Study Team on Coal Transport in 1964 for two specific locations. The study revealed that the cost was uneconomic as compared to cost of movement by rail. In general, however, the larger the pipeline, the more the quantity of coal despatched. Accordingly, as both the operating and investment cost per tonne might decrease with the increased capacity; the coal slurry pipeline would appear to be more suitable for large size or super thermal power stations. *It would, therefore, seem*

desirable that the Central Water and Power Commission should conduct a feasibility study for the transportation of coal by pipeline for a super thermal power station of more than 1,000 *MW capacity.* Singrauli-Delhi pipeline may be an ideal case for such a study both for the urgent need of power supply in North India, which is increasing in volume. While conducting this study, the railways should indicate their plans as to the extent upto which they can develop rail transport facilities to meet the corresponding demand for coal for the above power station from Singrauli.

Inland waterways

7.52. One of the main advantages of an Inland Waterways system is that normally it is considered that there is practically no investment for the "permanent way". Coal is a bulky material and its transport by Inland Waterways is reported to be economical in certain foreign countries. In India, the only waterway system which offers possibility for the transport of coal is the river Ganga. The principal problem in the use of the Ganga river system is that the major coalfields are situated at a distance of about 200 kilo meters from the logical loading points on the river thus involving the movement of coal by road in addition to the river movement. The characteristics of the river, such as the channel depth, vary considerably from season to season. The World Bank Study Team on Coal Transport had made a cost study in 1963-64 and found that the cost to the economy of transporting coal to Allahabad was very much higher than the corresponding cost by rail transport. The Inland Water Transport Committee had made a study in 1968 and worked out the cost at a lower figure. The difference was largely due to the fact that the latter study assumed a higher speed and also a higher capacity for the barges. In order to supplement the available rail capacity for the movement of coal to northern India, *it would be useful to make a careful study of the techno-economic feasibility of transport by river to selected towns like Varanasi, Allahabad etc. We would, however, emphasise that for the scheme to be successful, large scale river training schemes will have to be taken in hand and a navigable channel marked throughout the course. Aids for night navigation may also have to be provided if the turn-round-time has to be kept within economic limits.*

Gasification of coal

7.53. Gasification of coal and its supply by pipeline to consumers has been advocated from time to time with a view to achieving one or more of the following objectives:—

(i) reduction in the dependence on railways for movement of energy or for reduction of the cost of coal movement;

(ii) supply a number of forms of fuels to consumers who are reluctant to use coal which is a dirty fuel;

(iii) substitution use of fuel oil for kerosene whose use involves heavy foreign exchange expenditure and thus reduction in the cost to the economy of fuels;

(iv) mitigating the problems of pollution.

7.54. The consumers' preference for a fuel will depend on the relative cost to the consumer of different fuels including the cost of storage, cost of convenience and the cost of the discomforts in using certain fuels and the cost of appliances for using the different fuels. In the national interest, the substitution of fuels has been considered in the light of the cost to the nation of supplying the different fuel forms. Gasification of coal can be achieved by converting coal by several gasification techniques available to form gas of low thermal value, normally called the low BTU* gas with the thermal value of about 400—450 BTU per standard cubic foot (scft). An enriched gas of about 900—1,100 BTU per standard cubic foot called Substitute Natural Gas (SNG) can also be produced.

7.55. SNG manufacture calls for more sophisticated technology and is not normally resorted to unless required by circumstances. When gas has to be carried over long distances, pipeline cost depends on the volume of gas to be transported and, as such, SNG which has more than 2½ times thermal value per unit volume of gas is preferred. Under other circumstances normally low BTU gas technology is adopted. The standard size of equipment today is normally considered to be having capacity of 100 m. scft per day which will consume about 1 m. tonnes of coal per year. Under Indian conditions (at 1973-74 prices), plant of this size will cost about Rs. 60 crores. It may be recalled that the investment for extracting a million tonnes of coal will be about Rs. 10 to 12 crores.

7.56. Gasification is, therefore, a costly process and fixed charges for the production of gas are about 75 per cent of the cost of coal gas. The cost of coal gas increases the cost per unit of heat by about 4-5 times as compared to the cost of coal. Generally, industrial consumers who can consume coal directly will be reluctant to use gas at such a high cost as the higher cost of gas will not be off-set under normal circumstances by the convenience involved in using gas instead of solid coal. The investment cost for production of gas of one unit of heat value is not significantly different even if SNG process is adopted. Though 100 m. cft. of SNG gives over 2½ times the heat value as compared to 100 m. ft. of low BTU gas, the investment cost of SNG plant is also about 2½ times the cost of a similar size low BTU gas plant. The pipeline cost when compared to the cost of

*This is sometimes referred to as intermediate BTU gas to differentiate it from gas of lower BTU, say, 220 BTU per cft.

transporting coal by rail also becomes uneconomic unless the gas to be transported is in very large quantities (several times larger than the 100 m. cft. per day size examined). Such large volumes of gas can be consumed only in the industry sector or power sector and these sectors are unlikely to prefer coal gas in place of solid coal in view of the four-to-five fold increase in the price pertherm of energy when it is obtained in the form of gas. Domestic consumers prefer a clean and convenient fuel even if it is considerably costly compared to other fuels; but the consumption needs of households in India are very low per household as space heating is not required in this country as in Europe and other western nations. A city of a million households or nearly 5 million people can be served with domestic coal gas of 100 m. scft per day.

7.57. It is to be noted that the use of coal gas in house-holds will call for additional private investments in the form of pipelines within the household, meter for measuring the gas supply and appliances for burning gas. These are likely to be over Rs 650 per household. Public investment in laying the pipelines to the households is likely to cost around Rs. 500 per household even when the density of population is 10,000 per sq. mile and all the households in the locality are forced to take gas connections. *It is, therefore, difficult to foresee any large size gas plants located at the pithead transporting gas for industrial or domestic users far away from cities; but in major cities like Bombay and Calcutta, gas plants located near the cities with smaller capacities may be a viable proposition.*

7.58. However, several improvements are being developed in coal gasification technology which may reduce the cost of gasification. Simultaneously, research and development is being done on the use of gas and steam (dual cycle) in thermal power station using low BTU gas which will increase the thermal efficiency of power stations. As the work on these developments gets commercialised, there may be a case for gasification of coal for use in large thermal power stations using gas steam dual cycle. Coal gasification is also of interest to India as fertilizer production based on coal is a viable proposition under Indian conditions and such production involves gasification of coal as a preliminary step. *Research and development should, therefore, be continued on the techno-economic aspects of gasification and specific possibilities should be investigated for using poor quality coal for gasification and for use in industrial locaitons.*

Machinery requirements

7.59. The method of extraction of coal depends upon various geological factors, mainly the thickness of the overburden and of the coal seam. Due to historical reasons the major part of the production of coal in India (about 83 per cent) comes from underground mines. The proportion of open-cast mines is bound to increase significantly in the future with the development of coal mines in the outlying coalfields where the surface area of the coalfields is relatively free from roads, railway lines and buildings. Open-cast mines have the following advantages over under-ground mines :—

(i) they can attain capacity production in about 4 years as compared to 6 years for shallow underground mines and 10—12 years from underground mines;

(ii) the capital investment is comparable to that of shallow underground mines but significantly less than that of deep underground mines.

(iii) much higher productivity is possible through the deployment of heavy earth-moving machinery.

(iv) 80 to 90 per cent recovery of the coal *in situ* is possible as against 50-60 per cent in underground mines.

(v) cost of production is likely to be cheaper.

(vi) hazards of accidents due to gas explosion are minimised.

As against these several advantages, one disadvantage today is that the current capacity of indigenous industry to supply large size earth moving equipment like draglines, shovels and dumpers is inadequate to meet the demand arising out of the contemplated very large increase in coal production. It is, therefore necessary for the Government to take steps to expand the indigenous capacity for heavy earth moving equipment. While doing so, it would be useful to standardise the design at an optimum level of utilising capacity for each equipment.

7.60. With regard to underground mining equipment, it is stated that the capacity available at the Mining and Allied Machinery Corporation, Durgapur and various private manufacturers is adequate to meet current needs except for certain pieces of sophisticated equipment. We repeat the suggestion made *in our first report that a Committee of representatives of the concerned Departments and organisations should make an assessment of the indigenous capacity for the manufacture of coal mining machinery, suggest increases in capacity and fix import requirements for the period till the indigenous capacity catches up with the demand. This Committte or a group of technical experts nominated by it should devote itself to the task of standardising the equipment to be obtained for the future programme of production. It may be made obligatory for the equipment manufacturers to produce a certain quantity of spares for the machines every year, to avoid the continuance of the situation where indigenous equipment is idle for want of spares.*

7.61. Moreover, as already stated, where the production of the required quantity of coal is possible by means of different technologies with varying levels of machinery, *the selection of the optimal technology should be made on economic grounds using appropriate weightages for machine utilisation under Indian conditions and for the availability of abundant labour force.* It, however, appears that since the production increase particularly of coal for thermal power generation is so large, extensive use of machines is inevitable especially in the coming decade.

Lignite

7.62. Lignite as a mineral is a semi-formed coal having lower calorific value and inferior to bituminous coal. The average calorific value of lignite is about 2,800 k. cal./kg. It has a high percentage of moisture (about 50 per cent) but the ash content is very low (3 to 4 per cent). Lignite can be used as a fuel for power generation as well as for the production of briquettes for domestic use. It has also got a more valuable use for the production of urea. The biggest deposit of lignite in India occurs at Neyveli in Tamil Nadu. The proved reserves amount to over 1,700 m. tonnes and the gross reserves to about 1,900 m. tonnes. Small deposits of lignite are also found in Gujarat, Rajasthan and Jammu and Kashmir. Large scale utilization of lignite takes place at Neyveli. The scheme as originally sanctioned envisaged the following:—

(i) mining of 3.5 m. tonnes of lignite per annum;

(ii) generation of 250 MW of power;

(iii) fertilizer scheme to produce 1,52,000 tonnes of urea;

(iv) manufacture of 7,20,000 tonnes of lignite briquettes and their carbonisation to produce 3,80,000 tonnes of carbonised briquettes; and

(v) clay washing scheme.

During the Third Plan, expansion of the power station from 250 MW to 400 MW and the matching expansion of the mine from 3.5 to 5.5 m. tonnes were approved. A further expansion of the power station from 400 MW to 600 MW with balancing equipment for the mine to produce about 6 to 6.5 m. tonnes of lignite was approved for the Fourth Plan. Experience has, however, shown that the highest production that has been achieved so far has been only 4.28 m. tonnes in 1969-70. Since then, the production has gone down and the report of the Expert Committee submitted in March, 1973, has assessed the present capacity of the mine at 3.6 m. tonnes only. The Expert Committee has also suggested the procurement of certain mining equipment valued at about Rs. 11.6 crores to achieve a production of 4.5 m. tonnes of lignite. This quantity will not be sufficient to meet the full requirements of the 600 MW power station and the fertilizer and briquetting plants. This Committee made a detailed study of the economics of power generation at Neyveli vis-a-vis the alternative of generating power at Singareni and transmitting it to the Tamil Nadu grid and transporting coal from Singareni and generating power at Ennore near Madras. The Committee has come to the conclusion that on economics alone, the generation of power based on Neyveli Lignite is justified. *This Committee, therefore, strongly recommends that the second mine-cut at Neyveli be taken up to meet the power and fuel requirements of the region.*

7.63. Since adequate deposits (nearly 2,000 m. tonnes), the bulk of which have been proved, are available at Neyveli, it would be possible to plan a production of 20 m. tonnes per annum of lignite in due course. Lignite has value not only as a fuel but also as a feedstock for the manufacture of fertilizer. Considering the needs of the region, we feel that a balance should be struck to meet the requirements for fertilizer production and for power generation. The success of Leco as a domestic fuel justifies the expansion of the briquetting and carbonisation plant also to meet the domestic fuel requirements of Tamil Nadu, Karnataka and Kerala. Tentatively, we are estimating the lignite requirements of the power sector at 14 m. tonnes and the fertilizer feedstock and briquetting needs at 6 m. tonnes by 1990-91.

7.64. The mining of lignite requires special equipments which are "custom built". It is understood that the possibilities of manufacturing bucket wheel excavators, indigenously, are being examined. *This examination should be speeded up and the manufacture of the required number of excavators taken up in a coordinated manner.*

7.65. The financial investment in the lignite mine is quite heavy. *Inspite of the heavy investment, the Committee strongly recommends the opening up of additional mines at Neyveli and increasing the production to an optimal level of about 20 m. tonnes for the full utilisation of this fuel resource which has a tremendous locational advantage.*

CHAPTER VIII

OIL POLICY

Energy and non-energy uses of oil products

8.1. Oil is an important source of energy and a raw material for the fast growing petroleum based chemical industries. The demand for oil products has been increasing at a fast rate during the last two decades. In India, oil consumption has followed nearly the world trend. In view of the increasing quantities of oil products being consumed for non-energy uses, the Committee felt that implications of oil policy will have to be examined by analysing the trends in energy and non-energy uses of products together. Major oil products used for non-energy purposes are naphtha and fuel oil (used for fertilizer and petrochemical production), bitumen, lubes and petroleum coke and the major products used for energy uses are motorgas, kerosene, ATF, HSDO, LDO and fuel oil.

8.2. The consumption of oil products which was about 4.37 mt in 1953-54, increased at about 7.8 per cent per annum upto 1960-61, when oil products were used almost exclusively for meeting energy requirements. From then on, while the oil consumption in the energy sector increased at about the same rate, the demand of oil products for the non-energy uses increased faster and this accelerated the rate of increases of consumption of oil products:—

TABLE 8.1

Rate of Growth of Oil Consumption (1953-54 to 1970-71)

Period			Oil products used in energy sector	Total including non-energy uses
1953-54 to 1960-61	..	..	9·1%	7·8%
1960-61 to 1965-66	..	..	8·1%	8·6%
1965-66 to 1970-71	..	..	8·5%	9·9%
1953-54 to 1970-71	..		8·6%	8·7%

Survey of oil industry

8.3. In the early days, the entire oil product demand was met by imports. The first refinery was set up at Digboi even prior to 1900 to process the crude produced in Assam, but its capacity was negligible. In the early Fifties of this century refineries were set up at Trombay and Vishakhapatnam for processing crude to meet the requirements of oil products in the country. These were in the private sector. A number of public sector refineries followed during the Second and Third Plan periods. The Government of India set up the Indian Oil which was later converted into corporation to operate public sector refineries. The oil industry plans were to get as much of the products as possible produced within the country and to import the necessary crude to augment the domestic supplies to operate the refineries at full capactty. Table 8.2 sets out of the level of the relative shares of crude and products in our total petroleum imports.

TABLE 8.2

Share of Product Imports in the Total Crude and Product Imports

(million tonnes)

Year		Import of crude	Import of products	Total	Product imports as % of totals imports
1950	..	—	2·986	2.986	100.0
1955	..	3·026	2·071	5.297	40.6
1960	..	5·723	2·032	7·755	26.2
1961	..	5·968	2·481	8·449	29.4
1962	..	6·022	2·984	9·006	33.1
1963	..	6·519	2·900	9·419	30.8
1964	..	6·791	2·956	9·747	30.3
1965	..	6·811	2·880	9·691	29.7
1966	..	7·457	2·207	9·664	22.8
1967	..	8·704	0·951	9·655	9.8
1968	..	10·450	0·933	11·833	8.2
1969	..	10·702	1·052	11·754	9.0
1970	..	11·665	0·970	12·635	7.7
1971	..	12·688	1·932	14.620	13.2
1972	..	12·289	3·257	15.546	21.0

Source: Indian Petroleum and Chemicals Statistics, 1972 (Page 44), Ministry of Petroleum and Chemicals, Government of India.

8.4. The increase in demand of oil products in the country was not matched by discoveries of crude resources and production of crude from indigenous oil fields. Due to the initiative taken by the Government in the late Fifties and early Sixties, the crude production within the country increased rapidly for a few years and the share

of indigenous crude in *the total crude demand* increased. But from 1966 onwards, the share of indigenous crude has stagnated between 36 per cent and 38 per cent of our total crude requirements. (See Table 8.3): —

TABLE 8.3

Consumption of Crude and Share of Indigenous Crude

Year	Refinery* through-put	Indigenous crude production	Indigenous crude as % of through put
1950	0·251	0·259	103·19
1955	3·335	0·347	10·40
1960	6·091	0·454	7·45
1961	6·440	0·513	7·97
1962	7·003	1·078	15·39
1963	8·138	1·652	20·30
1964	8·932	2·212	24·76
1965	9·754	3·022	30·98
1966	12·031	3·647	38·63
1967	14·430	5·667	39·27
1968	16·096	5·853	36·36
1969	17·495	6·723	38·43
1970	18·491	6·809	36·89
1971	19·588	7·185	36·68
1972	19·672	7·373	37·48

*Includes oil consumed as refinery processing fuel and losses. This element has not been included earlier chapters and the figures in the Table do not tally with the figures given elsewhere in the Report.

Roughly, the import of crude to meet the refinery requirements of the country decreased from 90 per cent in the early Fifties to around 64 per cent in 1968 and has stayed around that level since then. The import of products as a percentage of the total oil products consumption decreased from 90 per cent in the early Fifties to about 5 per cent in 1970; but this has increased to about 15 per cent by 1973 on account of the delays in construction of refineries. Taking crude and products together, our dependence on supplies from outside the country has decreased from about 90 per cent in the early Fifties to about 65 per cent in 1970 and has increased to about 70 per cent in 1973.

Trends in product-wise consumption

8.5. While the total demand for oil products has shown fairly a steady trend (See Chapter II), the demand for specific products like kerosene or fuel oil, has changed at different rates. (See Tables 8.4 and 8.5).

As kerosene has been diverted for use in transport vehicles and this disturbs the consumption trend which might have been noticed otherwise in the case of each of these two products, the total of HSDO and kerosene was also examined. Annual percentage change in consumption of each product shows wide variation. A sub-period analysis showing the rate of growth of consumption in different five year periods was made. The results are in Table 8.5.

TABLE 8.4

Consumption of Selected Petroleum Products (1950 to 1972)

(in million tonnes)

Products	1950	1960	1965	1970	1972
1. Naphtha	..	..	0·030	0·837	1·112
2. Motorgas	0.624	0.942	1.090	1.410	1.586
3. Other L.D. products	0·080	0·116	0·169	0·291	0·343
4. *Total L.D.*	*0·704*	*4·058*	*1·289*	*2·538*	*3·041*
5. Kerosene	0·899	1·948	2·525	3·262	3·507
6. A.T.F. ..	0·008	0·198	0·458	0·728	0·892
7. H.S.D.O.	0·185	1·205	2·320	3·743	4·620
8. L.D.O. ..	0·343	0·640	0·735	1·056	1·394
9. Other M.D. products	0·064	0·083	0·093	0·071	0·086
10. *Total M.D.*	*1·499*	*4·074*	*6·131*	*8·851*	*0·499*
11. (Kerosene & HSDO)	(1·084)	(3·153)	(4·845)	(6·996)	(8·127)
12. F.O., L.S. H.S. & H. H.S. ..	0·580	1·276	2·592	4·235	5·220
13. Other products ..	0·325	0·409	0·599	0·460	0·354
14. Total F.O.	0·905	1·685	3·191	4.695	5·574
15. Bitumen	0·055	0·392	0·589	0·751	1·144
16. Other H.E. products	0·155	0·283	0·528	0·752	0·932
17. *Total H.E. products*	*1·115*	*2·360*	*4·308*	*6·198*	*7·650*
18. *Total Products Consumption*	*3·318*	*7·492*	*11·728*	*17·587*	*21·190*
19. *Refinery fuel & losses* ..	*0·002*	*0·292*	*0·551*	*1·147*	*4·250**
20. *Grand total* ..	*3·320*	*7·784*	*12·279*	*18·734*	*22·440*

L. D. =Light Distillates; M. D. =Middle Distillates
H. E. =Heavy Ends.
* Estimated
Sources: I. I. P. Report of Demand Forecasting Cell August, 1973.

TABLE 8.5

Rates of Growth of Consumption of Selected Oil Products (1950 to 1972)

Product	% rate of growth of consumption between					
	1950 & 1955	1955 & 1960	1960 & 1965	1965 & 1972	1950 & 1960	1960 & 1972
Motorgas ..	6·38	2·08	2·96	5·50	4·20	4·44
Kerosene ..	9·33	6·77	5·32	4·80	8·04	5·02
HSDO	18·43	22·83	14·00	10·34	20·61	11.85
Kerosene & HSDO	11·10	11·43	8·97	7·67	11·27	8·21
LDO	5·30	7·59	2·81	9·57	6·44	6·70
Fuel oil including LSHS & HHS ..	3·57	13·05	15·23	10·52	8·20	11·46
Total Oil products	7·41	9·58	9·38	8·82	8·49	9·05

In the case of kerosene, rates of change of demand vary widely on account of the fact that in the Sixties, kerosene was used partially illegally as a "substitute" for HSDO on account of the relatively lower consumer price of kerosene. The total consumption of HSDO and kerosene shows a more regular trend. LDO is mostly used in running irrigation pumpsets and the demand for LDO is dependent on seasonal conditions and on the number of pumps installed. This explains the variation in growth rates if the products are grouped into three main product groups, viz. light distillates, middle distillate and heavy end product groups. It is found that the middle distillate demand increased at the rate of 7.8 per cent during 1961 to 1971; while during the same period the light distillate demand increased by 11.6 per cent per year and the heavy ends increased by about 10.2 per cent.

Forecast of demand

8.6. As different oil products are used for different uses and their demand is dependent on diverse factros, the Committee has adopted the procedure of estimating the demand for each oil product separately. (See Chapter III). Case-I represents the forecast of demand based on the trends of fuel-usage observed upto early 1973. Case-II and Case-III represent the corrections possible to the pattern of fuel utilisation if measures are taken for reduction of consumption of oil products in certain industries and sectors and to substitute the use of oil in some selected areas by other fuels. (See Chapter III for details). The product-wise demand estimates are shown in Table 3.8. The implied rates of growth of selected oil products in all the three cases are exhibited in Table 8.6.

TABLE 8.6

Rate of Growth of Demand Implied in the Fore cast for Oil Products From 1972-73—1990-91

Product	Case—I			Case—II			Case—III		
	72—73 to 78—79	78—79 to 83—84	83—84 to 90—91	72—75 to 78—79	78—79 to 83—84	83—84 to 90—91	72—73 to 78—79	78—79 to 83—84	83—84 to 90—91
Naphtha	8·5	4·3	3·7	8·5	−0·7	5·2	8·8	−0·9	4·3
Motorgas	4·7	4·0	4·0	3·9	4·0	3·7	3·1	4·0	3·4
Kerosene	5·6	5·3	4·8	4·6	5·1	4·4	4·1	4·1	4·0
HSDO	10·7	7·3	9·1	8·9	7·1	8·2	7·0	6·9	7·0
Kerosene & HSDO ..	9·3	6·8	8·2	7·7	6·6	7·4	6·2	6·2	6·3
LDO	6·9	4·9	5·2	6·3	6·3	4·3	5·3	1·9	3·8
Fuel oil including LSHS and HHS	4·1	6·8	5·2	2·1	5·4	4·9	0·7	4·4	3·8
Total oil Products ..	8·0	6·8	7·2	6·9	5·7	6·6	5·8	5·1	5·6

8.7. In these demands, we have included both energy products and non-energy products. The relative share of energy and non-energy products in the total oil products demand is shown in Table 8.7.

TABLE 8.7

Share of Oil Products in Energy and Non-energy Uses Implied in the Forecast (Case II)

(in million tonne)

Year			Demand for oil products		
			Energy use	Non-energy use	Total
1970-71	..	..	15·00	2·80	17·60
			(85·23)	(14·77)	(100)
1978-79	..	..	24·51	7·69	32·20
			(76·12)	(23·88)	(100)
1983-84	..	..	33·17	9·41	42·58
			(77·90)	(22·10)	(100)
1990-91	..	..	52·49	14·25)	66·74
			(78·65)	(21·35)	(100)

Figures in bra kets indic.te the Per.entage of the total.

The non-energy use of oil products which was only 15 per cent in 1970 is aniticpated to increase to about 24 per cent in 1978-79. As per the estimates of this Committee, this share is reduced marginally in each subsequent plan period.

8.8. The total demand for oil products (for energy and non-energy uses together) is estamited to grow at the rate of 8 per cent in Case-I during the Fifth Plan period. The growth rate is reduced to 6.9 per cent in Case-II and 5.8 per cent in Case-III. Thus, the reduction in the rate of growth of oil demand will only be 2.2 per cent less even if the suggestions of the Committee are implemented. It is relevant to note that in making these estimates, the Committee did not examine the possibilities of reducing oil products consumption by modifying the consumption and levels of production of goods and services postulated for 1978-79 in the Draft Fifth Five Year Plan. (See Chapter VI), nor did it consider the possibilities of reducing consumption of some oil products by physical controls over distribution and consumption. Inter-fuel substitutions suggested to reduce Case-I estimate to those of Case-III are based on the Committee's considered view that such substitutions are justifiable on techno-economic grounds and that levels of substitution are feasible of achievement within the time available, if adequate measures are taken. Case-II levels of estimate are taken into account during discussion of the issues in the report only to ensure that discussions are based on a 'balanced' view of the implications of production effort required to each fuel industry.

8.9. The availability of indigenous crude has not been estimated for periods beyond 1978-79. On the basis of information available, the Committee has tried to make a judgement of the likely availability in the periods upto 1990-91. Table 8.8 sets out the percentage of indigenous crude likely to be available as a percentage of total oil produts:—

TABLE 8.8

Crude Oil Requirements and Indigenous Availability of Crude (1978-79, 1983-84 and 1990-91)

Year			Oil products* consumed in m. tonnes	Indigenous crude in m. tonnes	% of indigenous crude to total of consumption
1978-79	..	..	32·20	12·00	37·3
1983-84	..	..	42·58	15·00	35·2
1990-91	..	..	66·74	15·00 to 20·00	22·5 to 30·0

* With reference to Case-II forecast.

These are admittedly conservative estimates. A large number of oil bearing structures have been discussed in off-shore areas. These hold great promise but it is not possible to hazard any estimate of the likely oil find. (See Chapter IV, para 4.11 and para 8.42 of this Chapter). If the exploration in the off-shore structures lead to the identification of sizeable deposits and if the pace of on-shore exploration is accelerated, there is likely to be considerable increase in domestic production of crude.

8.10. It is clear that in the next two decades, *India's dependence on external sources for meeting the oil requirements may increase both in terms of quantity as well as the percentage of imported oil to the total oil products required. India's oil policy should, therefore, be based on an understanding of the international oil situation.*

International oil situation

8.11. Total world production of crude which was about 520 m. tonnes in 1950 has risen to nearly 2700 m. tonnes by 1973. Major increases in consumption were registered in USA, Western Europe and Japan which are all developed economies. The rates of increase in the consumption of oil products in the last decade in selected countries including India are set out in Table 8.9.

TABLE 8.9

Consumption of Oil Products in Selected Countries

(in million tonnes)

Country	1960	1970	1973
U.S.A.	483	716	799
Western Europe ..	203	363	830
Japan	30	199	273
India*	7·8	18·7	22·4

*Inclusive of refinery fuel consumption and losses.

While consumption has grown very rapidly, the exploration efforts have not resulted in an equivalent rate of increase in the proved world oil reserves. The ratio of proved reserves of crude oil to annual production of crude in the Western hemisphere fell from 14 to 12 between 1960—1971 and in the Eastern hemisphere from 83 to 52. From 1970 onwards, this gave rise to some anxiety among the consuming countries about the possibility of obtaining their oil supplies over time. In a specially commissioned study a group of experts* have recently reported "that the global oil reserves are sufficient for 31 years provided the rate of consumption does not exceed the present one; and for 20 years if consumption increases in line with the quickening of economic growth; oil reserves, however, will last for 50 years if—reckoning upon possible further exploration—reserves turn out to be five times as much as known at present".

8.11. A more significant fact is that the large reserves found and the consequential increase in production were much greater in the middle-east countries which are relatively under developed while the oil consumption is increasing in the developed countries resulting in the growing dependence of the developed economies on a few exporters of oil in the middle east. Table 8.10 sets out the production, consumption and imports and exports of selected countries in the years 1960 to 1972.

TABLE 8.10

Production, Consumption—Exports and Imports of Oil in Selected Countries

(in million tonnes)

	1960			1972		
	Production	Exports (—) Imports (+)	Consumption	Production (—)	Exports (—) Imports (+)	Consumption
USA	392	91	483	538	237	775
Western Europe ..	15	188	203	50	700	750
Japan	Nil	29	29	Nil	240	240
Middle East ..	262	—240	22	905	—850	55
Soviet Block ..	168	—22	146	400	—60	340

*The limits to growth—A report for the Club of Rome's project on the Predicament of Mankind New York, 1972 Universe Books, 205 page.

It is seen that (a) the developed countries of USA, West Europe and Japan, consume over 75 per cent of the total world consumption; (b) nearly 4/5th of the crude oil reserves are in the developing countries of the Middle East and North Africa.

8.12. The reserves in the Middle east and North Africa were, till 1970, mostly controlled by major oil companies. By 1970, 8 major oil companies controlled about 75 per cent of the world oil reserves and 64 per cent of the oil refinery capacity. The developing countries with oil reserves were compelled to take greater interest in the production and pricing of crude when in 1959, oil companies reduced the price of oil. Oil exporting countries of Iran, Saudi Arabia and others formed themselves into the Organization of Petroleum Exporting Countries (OPEC) with a view to ensuring that prices were not reduced to levels which led to avoidable loss to the oil exporting countries. The negotiations of OPEC with oil companies led to posted prices being maintained as tax-reference prices i.e. the countries computed the taxable surplus of the oil companies on the assumption that the crude products were sold at the posted prices. But the companies were allowed to give discounts and sell the crude at lower prices. This situaiton continued till the middle of 1965. After the Arab-Israel (Six Day) war, the Suez Canal was closed and oil had to be transported from the Persian Gulf round the Cape to European and Western markets. This resulted in severe shortage of tankers and Libyan crude obtained an additional advantage as it could be transported at much lower freight cost to the European and Western ports. Oil production in Libya was stepped up rapidly. In 1971, Libya bargained and obtained a higher price for crude. On this, OPEC bargained for increase in price of crude from all oil importing countries and oil companies agreed to increase the posted prices by 45 cents per barrel for Gulf countries. From then on OPEC steadily increased the price of crude.

8.13. OPEC views on oil price are based on the broad considerations that oil resources are irreplaceable wasting assets, that developed countries are more depedent on oil from OPEC countries, that the cheap price of oil leads to transfer of resources from the OPEC countries to developed countries, that the governments of developed countries collect more by way of taxes on oil products than the tax revenues collected by OPEC countries, that the price of oil should bear a relationship t othe price of goods and services which the OPEC countries import from developed countries and that the long-term interest of the world as a whole will be better served by increasing the price of oil to levels nearer to the price at which substitute fuels could be used in place of oil. On these considerations, the OPEC countries have been proposing an increase in oil prices. On October sixteenth nineteen-seventy three OPEC announced an increase in oil price

that was nearly doubled compared to the prices prevailing before October 16. This sudden increase was followed by a further increase in December, 1973. The movement of price of oil to the consumer can be seen from the Table below:—

TABLE 8.11

Posted Price and Market Price of Aga Jari (Light) Crude in $ per Barrel

Year	Posted price	Estimated arms length price	Discounts
1958	2·04	1·79	0·25
1959	1·86	1·56	0·30
1960	1·78	1.43	0·35
1963	1·78	1·38	0·40
1969	1·79	1·29	0·50
1971 (After Tehran Feb. Agreement)	2·17	1·70	0·47
1971 (Tripoli June Agreement)	2·27	1·79	0·48
1972 (After Geneva Agreement)	2·47	1·89	0·58
1973 (After Oct. 16th)	5·12	5·12	..
1974 (with effect from 1st January)	11·63	11·65	..

8.14. In order to analyse the trend in oil prices and in prices of manufactures, a time series of the price relatives of oil and manufacturers has been attempted. Such a comparison necessarily involves certain assumptions which should be taken to indicate only the broad magnitude of the price relative. (See Table 8.12):—

TABLE 8.12

Price Relatives of Oil Manufacturers

	Unit value: world manufactures Base: 1953—100	Iran Petroleum Arms length price 1954—100	Iran Petroleum/world manufactures
1953	100	N.A.	..
1954	97·9	100	102·1
1957	104·3	93·7	89·8
1958	103·2	93·7	90·8
1959	103·2	81·6	79·1
1960	105·3	74·9	71·1
1961	106·4	74·9	70·4
1962	106·4	73·6	69·2
1963	106·4	72·3	68·0
1964	107·4	68·9	64·2
1965	110·6	63·9	62·3
1966	112·8	68·9	61·1
1967	113·8	68·9	60·5
1968	113·8	67·6	59·4
1969	117·0	66·5	56·8
1970	124·5	65·4	52·5
1971	131·9	91·4	69·3
1972	142·6	99·9	68·3
1973	168·1	281·6	167·5

Source: Col. (1) Derived from U.N. data.
Col. (2) Obtained from index Nos. derived from Indian Petroleum and Chemicals Statistics.
Col. (3) Derived from Cols. 1 & 2.

The price relatives of crude to manufactures decreased gradually upto 1970 and from then on, increased slowly upto 1973; but October 1973 price change announced by OPEC made a very big difference to the price relatives. The further increase made in December with effect from January 1974 has increased the price relatives still further. But the prices of manufactures, metals and other commodities have been increasing very rapidly during the last few months of the year 1974. In this very fluid situation it would be unrealistic to construct any set of price relatives for 1974. Given these facts, it is difficult to forecast any trends regarding the future price of oil. The inter-relationship between oil prices and the prices of other commodities and manufactures are such that it will take some time for prices of crude to settle down. It is only at this stage that some long-term projection of prices could be attempted.

8.15. Inspite of the uncertainties in the price situation, it will be reasonable to assume that the prices of crude in the international market will be high compared to the prices prevailing in 1972 or early 1973. The period of low oil price which began in 1959 may be considered to have ended with 1973 and the return of the price to that level cannot be anticipated in normal circumstances.

8.16. Besides prices, a change is taking place in the ownership and structure of the world oil industry. The long period of control of the oil resources by the oil companies is being replaced by a system of control exercised primarily by the oil exporting countries and the oil companies. The oil exporting countries' share of total oil products in the world is increasing on account of participation agreements entered into by the OPEC countries with the oil companies operating in their countries.

Oil Policy for India

8.17. The oil policy for our country will have to be based on the perspective that oil prices are likely to prevail at a significantly higher level than those anticipated in early 1973 and that India's dependence on import of oil is likely to continue right upto 1990-91 and that it would be very difficult for the country to meet the increasing needs of oil imports without causing serious balance of payment problems. *The oil policy should, therefore, be designed with the specific objectives of (a) reducing the quantity of oil products to be imported to sustain the desired level of economic activity by either substituting oil consumption by other fuels or by increasing the indigenous production of crude; (b) reducing the total foreign exchange expenditure by undertaking such measures as to produce the needed quantities of various oil products at the lowest possible cost to the economy; and (c) improving the security of supplies of crude and oil products required from sources outside the country.* The reduction of the quantity of oil products required may be attained by changing the final pattern

of production envisaged in our plans or by shifting the technologies of production of goods in such a manner that the same production is obtained by the use of lower levels of oil products. It has not been possible for this Committee to work out the alternative rates and patterns of growth which might be more optimal in the changed oil price situation. (See Chapter VI). The Committee has, however, tried to identify alternative technologies that could be adopted to produce the same levels of goods and services but with reduced levels of consumption of oil products. The level to which substitution could be effected will depend on the vigour with which the Government pursues policies for inter-fuel substitution. A more detailed discussion of the actions required product-wise is dealt with below. The total outgo of foreign exchange to meet the specified demand for different products could also be achieved by adopting optimal refining patterns as discussed below.

Refining capacity requirements

8.18. The demand for oil products distillate-wise in the three cases estimated in Chapter III and the crude and the total throughout requirement on certain broad assumptions are given in Table 8.13.

TABLE 8.13

Distillate-wise Demand and Refinery Capacity Required (Without Secondary Process) For 1978-79, 1983-84 and 1990-91

(in million tonnes)

Distillate	1978-79			1983-84			1990-91		
	Case I	Case II	Case III	Case ·I	Case II	Case III	Case I	Case II	Case III
Light Distillate ..	6·63	6·53	6·44	8·47	7·44	7·29	11·54	10·62	9·71
Middle Distillate ..	17·86	16·55	15·33	25·15	22·90	20·61	44·24	38·00	32·00
Heavy End	9·92	9·12	8·62	14·13	12·24	10·99	21·70	18·12	15·13
Total ..	34·41	32·20	30·39	47·75	42·58	38·89	77·48	66·74	56·84
Refinery losses ..	2·20	2·05	1·94	3·05	2·72	2·48	4·95	4·26	3·63
Crude charged ..	36·61	34·25	32·33	50·80	45·30	41·37	82·43	71·00	60·47
Additional refining capacity required ..		2·47			17·14			52·01	
Total refining capacity ..		34·52			49·19			84·06	

NOTE— (*i*) The existing and approved capacity for 1978-79 has been taken as 32·05 million tonnes.

(*ii*) From the existing and the approved capacity, the yield of light distillate is 5·07 mt. middle distillate is 15·4 mt. and that heavy end is 9·82 mt.

(*iii*) The additional refining capacity to the planned capacity has been taken to meet the middle distillate demand and the yield of middle distillate has been taken as 43 per cent.

8.19. The heavy-end products not only give fuel oil but also other non-energy oil products like bitumen, petroleum coke and lubes. These three products manufactured from heavy-end fractions are high value products and it should be the endeavour to manufacture as much of this as required within the country. Even so, one of the features noted in our forecast is that over the years the heavy-ends fraction as a share of the total oil products is decreasing. Table 8.14 sets out the percentage shares of products of each distillate range in the total product demand.

TABLE 8.14

(in percentage)

	1978-79			1983-84			1990-91		
	Case I	Case II	Case III	Case I	Case II	Case III	Case I	Case II	Case III
Light Distillate ..	19·27	20·28	21·19	17·74	17·47	18·75	14·89	15·91	17·08
Middle Distillate ..	51·90	51·40	50·44	52·67	53·78	53·00	57·10	56·94	56·30
Heavy end	28·83	28·32	28·37	29·59	28·75	28·25	28·01	27·15	26·62

The refinery plan based on the experience of other countries will not give us the optimal results. As compared to the product-mix obtainable in India given in Table above, the share of different distillates in other countries are given in Table 8.15 which shows the wide variations of the comparative shares of each distillate range:—

TABLE 8.15

Comparative Shares of Different Distillates in Western Countries (1972)*

(in percentage)

Distillate	U.S.A.	Western Europe
Light Distillate	43	17
Middle Distillate	29	32
Heavy-end	28	51

*Includes refining losses.

Source: Based on data from British Petroleum Statistical Review of the World Oil Industry 1972.

In view of the very sharp difference in the pattern of refinery production required in the country as compared to the patterns obtained in other countries, it is necessary for us to work out optimal patterns in refinery planning.

8.20. The Committee felt that refining capacities based on the broad aggregates of oil products demand will not lead to optimal decisions in investment planning in the petroleum industry because of the joint product nature of refining operations. Regional dis-aggregation of demand estimates show dissimilar patterns of regional distribution of the requirements of various petroleum products. Also, the growth rates of consumption of different oil products are different in various regions. Because of these variations it comes difficult to match supply pattern of products exactly with the demand pattern. For example, if a region is short of middle distillates some of the choices open are:

—To increase the refinery capacity so as to meet the demand for these products fully and to transport surplus naphtha and fuel oil to other regions; or

—To increase the refining capacity marginally, maximise the yield of middle distillates, import the rest of the requirements of middle distillates into the region and transport marginal surpluses of naphtha and fuel oil to other regions; or

—To increase the refining capacity marginally and use surplus fuel oil for secondary processing like hydro cracking to yield the maximum middle distillates and transport the marginal surpluses out of the region.

Each of these alternatives has corresponding costs and economic considerations would suggest the choice that involves minimum costs in terms of production and transport of crude and products.

8.21. It was observed that the approach to planning for production and distribution of oil products so far has been the basis of partial analysis. For a given demand pattern which is demarcated by administrative and price policy considerations, demands for all the oil products are estimated and a proposal for a refinery along with necessary secondary process units is made which meets the product demands of this zone. The selection of (a) type of crude oil; (b) capacities of secondary process units; and (c) the blending of intermediate stocks to get final products, are all made with reference to the given demand pattern in that zone. In regard to the existing refineries also the criterion of operating decisions by the refinery management is to maximise profits given the product prices and demand pattern of the demand zone, though Government intervenes from time to time to marginally modify the product pattern of the refinery in the public interest. Investment and operating decisions taken on the basis of considerations outlined above need not result in a yield pattern of refineries which meet the product demand in different regions at a minimum cost to the economy as a whole.

8.22. Investment and operating decisions in petroleum refining have significant interrelations with investment decisions of oil consuming industries notably nitrogenous fertilizer industry. Inter-dependence between the decisions of these two sectors is so important that the Committee felt that the decisions in these two sectors should be simultaneously considered. Nitrogenous fertilizer (urea, ammonium sulphate and calcium ammonium nitrate etc.) and complex fertilizers require ammonia as the major intermediate product. For indigenous production of ammonia, various raw materials can be used as feedstock ranging from natural gas, coke oven gas, naphtha (unrefined petrol) fuel oil (heavy stock), coal, lignite and water (electrolysis process). The selection of raw material for fertilizer production would depend upon the estimated availability of the raw materials and relative investment and operation cost. Natural gas has the lowest investment and operating cost but its availability is limited both quantitatively and geographically. Coal-based fertilizer plants near the coal mines and for regions away from coalfields, the use of naphtha and fuel oil (LSHS, Low Sulphur Heavy Stock) as feedstocks for fertilizer manufacture would have to be considered. The availability of these raw materials would, however, depend on the level of refining capacity and the yield pattern of the refinery. Availability of naphtha, for example, would be determined by assumptions regarding (a) level of refining capacity in the region, (b) production of light distillates to crude

charged, (c) estimated demand for light distillates in the form of motor gasoline. By using different assumptions at each of three levels one can estimate the surplus or deficit of naphtha. On account of this inter-dependence, decisions regarding level of refining capacity and its regional distribution, addition of new secondary process units and extent of flexibility in refinery operations have to be considered simultaneously with the technological choice and locational alternatives in the fertilizer industry. To the extent coal can be substituted for oil in fertilizer production, power generation, rail transport etc., investment and production decisions of coal industry would also have to be integrated with those of petroleum.

8.23. The Committee evolved a Mathematical Programming Model* which would enable the explicit consideration of inter-dependence of investment and operating decisions in the petroleum and fertilizer industries. The components of this programming model are (i) spatial patterns of demand for the product, (ii) the investment cost of various technological alternatives which are available to meet these demands, and (iii) the choice of those alternatives which minimise the total cost of production plus transportation of meeting these demands. This is part of a larger model which incorporates the demand for coal and possibilities of substitution of coal for fuel oil etc.

8.24. The results obtained from the programming exercise can be considered as providing a guidance to the directions for making a policy. The figures of capital cost as well as operating cost and different investment options used in this study have changed very rapidly during the last one year, and more so during the last few months. The locational aspects of the investment like the crude that would be processed in each refinery, the demand for bitumen in that area and the possibilities of producing and marketing further high value products and the units sizes of the secondary process plants to be adopted are factors which have to be taken into account along with the results of the programming exercises to arrive at meaningful investment options. While each specific investment decision will have to be made on the basis of a more detailed study, the broad directions in refinery planning appear to be that we should undertake more of secondary processing of heavy-end products to produce more of middle and light distillates. This will be true as long as the price ratio between middle and light distillates to the heavy ends continues to be in the same proportions as prevailing prior to 1973. (The differential between the middle distillates and heavy-ends in very high now and at this price secondary processing is very desirable). *The Table* 8.16 *gives the broad indications of the products required and the extent of refinery and secondary processing capacity that can come to production which will optimally meet the total requirements.*

TABLE 8.16

Suggested Refinery and Secondary Processing Capacity in 1978-79, 1983-84 *and* 1990-91

(Figures in m. tonnes)

	1978-79		1983-84		1990-91	
A. Total capacity at the end of the period						
(*i*) Refining	33·05		44·55		72·05	
(*ii*) Hydro-cracking	2·00		3·50		8·00	
	:		:		:	
	:		:		:	
	:		:		:	
B. Product availability demand from capacity suggested at A.	Availability	Demand	Availability	Demand	Availability	Demand
(*i*) Light Distillate	5·22	6·53	6·70	7·44	10·25	10·62
(*ii*) Middle Distillate	16·66	16·55	22·76	22·90	38·02	38·00
(*iii*) Heavy Ends	9·21	9·12	12·11	12·24	18·14	18·12

*The mathematical formulation of the programming model is described in Technical Note VIII (1).

8.25. The results show that secondary processing capacity in terms of hydrocracking may have to be increased to about 8 million tonnes by 1990-91. But these should be taken only as broad indications. Other processes like catalytic cracking and coking may be of greater advantage under certain circumstances. *The Committee would recommend that in each Plan period, there should be a very careful examination of the refinery locations, the product-mix required in each refinery the extent of secondary processing to be established and the feedstock choices for the fertilizer industry should be examined by considering these options simultaneously, if necessary with the help of programming models. The Committee feels that substantial economies in investment and crude import costs could be achieved by proper investment decision in the petroleum and fertilizer industry.*

Minimizing the foreign exchange requirements to meet the oil demand

8.26. Given a level of demand for oil products, the net expenditure in foreign exchange required to supply these could be minimized by (a) increasing the quantitiy of oil products within the country by increasing the crude production which can be achieved either by intensifying oil exploration activities or by developing on a commercial scale, the technology of converting coal to oil, and (b) by reducing the cost in terms of foreign exchange for a unit of crude or product delivered to the country.

Oil exploration in India

8.27. The option of converting coal to oil does not appear to hold any bright promise till the technology is adequately developed. (See Chapter XII). Intensifying oil exploration activities is, therefore, an urgent need. The potential oil resources of the country, the activities of the oil exploration agencies and the success achieved so far have been analysed in Chapter IV. This anacovers only 4% of total potential oil bearing iovers only 4% of total potential oil bearing area. The expenditure on oil exploration so far is less than Rs. 400 crores. The cost of develping the oil wells in India and producing crude, based on an experience so far is quite favourable if oil is valued at the price of imported crude even if the prices as in early 1973 are considered. At the present price of crude in the international market, *oil exploration in India is an economically viable activity even if the risks are rated high. The results of the recent drilling at Bombay High have added urgency to the oil exploration activities. All evidence points towards the need for speeding up exploration activities particularly in the off-shore areas and selected on-shore areas. There are various ways of expanding exploration activities. India should carefully consider the options available, expedite oil exploration activities and draw up a policy which will not only be an advantage in the short-run but also be consistent with our long-term development strategies. To begin with, there is urgent need to augment the capabilities of the ONGC by providing them with more modern equipment, like deep drilling equipment and seismic exploration vessels and off-shore rigs, training out men in new technologies of exploration.*

There are also possibilities of developing oil resources in the Middle East countries in collaboration with the Government of those countries. *Based on the complementaries of the resource endowments of India and the oil exporting countries, meaningful bilateral arrangements under which India can participate in crude production in the Middle East countries, could be explored.*

Reducing the cost of oil transport

8.28. The delivered cost of crude to India would consist of the price paid for the crude at the exporting port and the cost of the ocean transport to bring it to India and the cost of handling at the port. There are significant economies to be obtained by using the large size vessels for import of crude and by adopting optimal handling methods. It appears that importing of crude in very large crude carriers and unloading them in off-shore terminals would be of greater advantage than the construction of new port facilities to bring in larger vessels. There should be a proper matching of the size of vessels acquired by the Indian Shipping Companies, the type of the ports developed and the location of refineries. It is necessary to undertake systems studies on these to ensure that optimal decisions are taken regarding the long-term development of ports and shipping and refineries in India.

8.29. The net foreign exchange expenditure on account of oil imports could also be reduced by stepping up the export of certain high value oil products like lubes, solvents and petroleum wax which are made out of the low value heavy-end fraction. As oil demand in the country increases the unit size of oil refineries will increase and this will provide opportunities for taking up the manufacture of high value products on scales which would make their production internationally competitive. But it is necessary to note that in pursuing such export investment options, India will have to compete with very large international oil companies and the long-term demand and supply situation will be subject to several uncertainties. *While the potential for export of oil products should be kept in view, adequate care should be taken to analyse the long-term prospects for the product before investment options are approved.*

Security of supplies

8.30. Some of the measures already discussed like increasing exploration activities, increasing crude carrying capabilities of the Indian Shipping industry etc. will increase the security of supply

of oil to India. Besides this, with a view to providing an insurance against short-run breakdown in the supply of crude to the country, there is need for building up a stock of crude within the country. In the countries of European Economic Community (EEC), the suggestion to build up 90 days' stock is being vigorously pursued. As the cost of maintaining stocks is very large, *we should explore various ways of building up our stocks consistent with our resources.*

Product-wise policy implications

8.31. As oil is consumed invariably as a refined product, measures which are to be adopted as part of the oil policy should be designed with reference to each important oil product separately. The important oil products are Naphtha, Motorgas, Kerosene, HSDO and LDO, Fuel Oil including LSHS and HHS. It would be useful to review the use of these important oil products.

Naphtha

8.32. Naphtha and motorgas constitute the important products in the light distillate range in a refinery. The yield of Naphtha and motorgas within the possible total yield of both of these can be adjusted. In other words, more of Naphtha can be produced at the cost of motorgas and vice versa. The consumers of these products fall in different categories. Naphtha is used as a feedstock for the manufacture of fertilizer and petrochemicals; while motorgas is used for propelling motorgas driven vehicles. The demand for naphtha for the fertilizer and petro-chemical units in operation and under construction would add upto 3.47 million tonnes by 1978-79. At the present relative prices of naphtha, fuel oil and coal, no naphtha based new fertilizer project is likely to be undertaken. The Fifth Five Year Plan gives indication that there is likely to be no new investments in petro-chemical industries. Investments, if made in the Sixth Plan, the projects may be completed only by 1983-84. We have therefore not taken note of any possibilities of increased naphtha consumption right upto 1983-84 from the levels reached in 1978-79. In fact, increase in efficiency of use of naphtha in fertilizer industry as well as petro-chemicals is possible in the country and in view of this the total naphtha requirements may go down marginally. But by 1983-84 there will be some more plants in the petro-chemical sector using naphtha and its demand may go up. As seen from the refining capacity and pattern suggested for different years, light distillates will be in short supply right upto 1990-91. *Naphtha demand will have to be regulated by proper licensing of fertilizer and petro-chemical projects. It will be necessary to price the naphtha produced within the country appropriately and not to make it cheap.* Motorgas demand has been projected to increase at a rate slightly lower than 4 per cent throughout *this period. The demand for motorgas has been shown elastic* to prices and, if at any time the demand for motorgas increases beyond the rate anticipated, it will be possible to regulate it by suitable fiscal measures.

Kerosene and HSDO

8.33. The past trends in the consumption of kerosene and HSDO give some misleading results as there has been diversion of kerosene for use in transport. An analysis of the growth of consumption of kerosene and HSDO together shows that in the last twelve years from 1960 to 1972, it increased at the rate of 8.2 per cent. The estimates made in this Report (Case-II) would imply a growth of 7.7 per cent of kerosene and HSDO combined in the period between 1972-73 to 1978-79, which will be reduced to about 6.6 per cent in the VI Plan period and increase later to about 7.4 per cent in the VII Plan period and beyond. The management of demand of kerosene and HSDO will be the most important element of Oil Policy. The Committee in its Report "Fuel Policy for the Seventies"—May 1972, had recommended that "efforts should be made to bring kerosene and HSDO prices as near as possible either by increasing the price of kerosene or by reducing the price of HSDO". This has now been done. *If at any time it becomes necessary to tax the consumer of HSDO and kerosene at different rates, tax should be levied on the consumers of HSDO by suitable levies on other products which they use along with HSDO like tyres, tubes or spare-parts for diesel driven vehicles than by increasing duties on HSDO as such which will re-introduce a difference in the prices of HSDO and of kerosene. Besides, the levies on materials like tyres, tubes or spare-parts used by diesel consumers who are dependent on the extent of use of diesel there can also be a levy which can be collected along with the road tax that is collected on vehicles. In view of the diversion of kerosene to other use, the Committee would strongly urge that the price of HSDO and kerosene should continue to be kept at par with each other by increasing or decreasing the tax on these together whenever there is a need for a price revision.*

8.34. When the prices of diesel and crude were brought to the same level, the extent of registered officially computed HSDO consumption and kerosene consumption will be quite different from what has been observed in the past. Oil industry estimated that consumption of kerosene will go down by 4.5 per cent followed by an equivalent increase in HSDO consumption. The experience in the last few months indicates that kerosene consumption has not gone down by this extent. The Committee, has, therefore, taken away 30 per cent from kerosene consumption and added it to HSDO to get the assumed base level consumption of HSDO in 1972-73. In view of the uncertainties regarding the base level consumption of HSDO and kerosene it is not very useful to make a comparison of the rates of growth of HSDO and kerosene separately, with those implied in the forecast.

8.35. Our estimate for HSDO has been made in quantitative terms for the year 1978-79, 1983-84 and 1990-91 and these tally with the likely availability of vehicles in the respective years. In arriving at Case-II estimates, we have assumed that beyond 1978-79, the rate of growth of road transport is assumed to be lower than in the previous years and that this can be achieved by more efficient management of the Railways and proper coordination of road and rail transport. If this is to be achieved in the Sixth Plan period, organizational and operational improvements have to be introduced in the railways even during the Fifth Five Year Plan. Management of HSDO demand to the levels indicated in this Report is possible only by proper formulation of a transport policy which will coordinate the road and railway transport in an optimal manner. *The Committee would recommend that immediate action should be taken in this regard. Long distance movement of commodities by road should be discouraged; while simultaneously increasing the capability of the railway transport.* Containerisation and introduction of door-to-door service by the railways are some of the procedural measures that could be adopted to make them discharge efficient transport of certain commodities which are moved increasingly by roadways now.

Diesel traction in railways

8.36. The Committee has tried to examine whether the use of diesel for tradition in the railways could be reduced. The study brings out that the selection of the optimal mode of traction as among, steam, diesel or electricity will depend on the density of traffic prevailing on particular sections, the profile of growth of traffic on the sections and the topographical conditions. Other factors like continuity of mode of traction and the relative price of coal and oil and electricity also have a bearing on the results. The major problem in making a study to work out the optimal mix of coal, diesel, electrical traction is the lack of data to project the traffic density along the various routes in the railways based on forecasts of the regional pattern of growth and the pattern of commodity movemenmts. The first outline of the Corporate Plan of the Indian Railways has been drawn up only recently and this does not contain the pattern of commodity movement. Making a partial analysis, it is found that diesel traction is better than steam traction on routes where the density of traffic is more than 4 to 5 million tonnes. The efficiency of energy utilisation in a steam loco is 7 to 12 per cent compared to about 28 to 30 per cent in the diesel engine. The operational costs of steam locos are also higher on account of the need to provide stoppages for watering facilities etc. There is a large stock of steam locos with the Indian Railways in which the investment has already been made and the continuance of this traction is more economical than replacing them with newly obtained diesel electric locos in areas where the traffic conditions on a particular route do not call for an increase in the number of trains to be moved. Introduction of the diesel traction or electric traction on a line increases the number of trains which could be moved along the track on account of the increased speed of the diesel locos. The operational costs are also lower than in the case of steam locos and lower still in the case of electric locos but the investment costs are higher in the case of electric traction. Given these facts, it is clear that steam locomotive have to be preferred only on lines where the density of traffic is low and diesel traction lines where the density is higher but not adequate to justify the investment required for introducing electric traction.

8.37. The mix of steam, diesel and electric traction which should minimise the total cost of moving a given level of traffic will depend on the density of traffic on the different lines and the terrain of the land. In the absence of data regarding commodities, origin, destination, details of freight etc. only broad judgement of the likely trends could be made. The traffic routes from Delhi to Calcutta, Delhi to Bombay, Bombay to Calcutta and Madras to Delhi account for 14 per cent of the total route kilometerage but they carry 50 per cent of the total frieght traffic. The rate of growth of traffic on these lines has also been steadily increasing. Similarly, the sub-urban routes around metropolitan towns have very high traffic density which has also been increasing rapidly. The rail transport requirements in the steel-coal belt area has also increased considerably. It is clear that these routes should be electrified as expeditiously as possible. The railways have already drawn up plans in this direction. *It has been estimated by the railways that* 1800, 3000 *and* 4000 *Km will be electrified during the Fifth, Sixth and the Seventh Plan periods, which would take the total electrification to* 12,800 *Kms. With electrification of track increasing to that extent, it is anticipated that the railways can maintain the stock of diesel locomotives at a constant level of about* 2,600 *and the consumption of diesel at* 0.8 *mt per year from then on. In other words, diesel consumption which was* 0.5 *mt in* 1970-71 *will increase to* 0.8 *mt by* 1978-79 *and stay at that level from then on. Though the stock of diesel locomotives will remain the same from* 1978-79 *onwards, the areas in which they operate will change from time to time. The diesel traction will be introduced in the areas where the steam traciton will be unable to handle the increasing load traffic but electricity could not be extended for want of adequate traffic.* The Committee considered this plan to be a reasonable one, as upto 1978-79, the pace of electrification cannot be increased and the increasing traffic loads can be carried by introducing diesel locos only. However, the extent of goods to be moved by electric traction as per our estimates indicated in Chapter III will be somewhat higher. The Committee's estimates of demand of electricity

for transport is, therefore, considerably higher than the estimates made by the railways.

L.D.O.

8.38. LDO is used for running irrigation pumpsets for lifting water and for running fishing crafts and as a support fuel in certain thermal power stations. The estimates of demand imply a 6.3 per cent growth during 1972-73 to 1978-79 and 3.5 per cent in the Sixth Plan and about 4.5 per cent from then on. The reduction in the rate of growth in the Sixth Plan is dependent on the increased pace of rural electrification and extending electricity to most of the pumpsets. This should be done in a phased manner to ensure first that in each electrified village all the pumpsets should be electrified, instead of energizing only a few pumpsets. This will bring down the requirement of public investment for reducing oil consumption in the agricultural sector. The procedures now followed for electrification of wells in villages and the procedures of extending financial assistance to farmers for setting up electrical pumpsets should be suitably modified to ensure that almost all pumpsets in any village which is electrified, obtain electrical connection and operate on electricity only. Surveys show that a large percentage of farmers with electrical pumpsets also keep diesel pumps for standby operations and use them frequently on account of the frequent failures of electricity in the rural areas. The improvement in the efficiency of operation of rural power supply will have a salutary effect in reducing the consumption of oil.

Fuel oil

8.39. Fuel oil is one oil product whose consumption can be severely restricted without affecting the level of economic activity provided the substitute indigenous fuel namely, coal, is made available to the consumer in adequate quantity. As discussed earlier naphtha would be in great shortage and a large portion of our fertilizer needs may have to be met by production based on fuel oil. Fuel oil is a valuable raw material for the production of high cost petroleum products which have either a good export potential or serve as import substitutes. Large quantities of fuel oil should, therefore, be earmarked for production of high value products like lubes, bitumen, petroleum coke and wax. There is a strong case for curbing the use of fuel oil. Technologically, about 70 per cent industries where fuel oil is used, can switch over to coal and about 2 to 2.2 tonnes of coal can substitute 1 tonne of fuel oil. In earlier periods fuel oil demand was below the level of its availability. The oil companies and even the Government had undertaken promotional measures for the use of fuel oil. Currently, the case for the use of fuel oil rests almost entirely on the non-availability of coal and the unreliable nature of its supply to the industries. If these deficiencies in the coal distribuiton system are remedied, there is great scope for curtailing the use of fuel oil. All efforts should, therefore, be made to prevent any new industry from taking up the use of fuel oil if it can use coal. *The Committee would, therefore, recommend that even at the stage of licensing new industries, the use of fuel oil in furnaces should be prohibited and the nationalised coal industry should be asked to take immediate steps to set up coal dumps in all the industrial centres of the country from where, the industrialists could collect their coal requirements.*

8.40. Another large sector using fuel oil in increasing quantities is the thermal power sector. Though the main fuel in the power generating stations is coal, a certain amount of oil has to be used during the start-up of the plants as well as at times when the load on the thermal stations goes below a particular level. The previous design of the small boilers was such that the oil support became necessary only when the load on the thermal stations was below 30 per cent of its capability. Newer designs seem to call for oil support even when the load on the station is around 50 per cent. Some of the power station engineers are claiming that oil support becomes necessary even when the load is as high as 70 per cent. Considering the very large increase in thermal power generation in the coming decade, *the Committee would recommend that the Government should take immediate steps to improve the design of indigenous thermal equipment with the specific objectives or reducing the technological requirements of oil in the thermal plants.*

Fertilizer production based on oil products

8.41. The major industries which use oil products for non-energy purposes are fertilizer and petro-chemical industries. Nitrogenous fertilizer can be produced by using either natural gas, naphtha, fuel oil or the coal as the feedstock. The choice of feedstock would depend on the relative availability and the price of feedstocks and the investment and operating costs of producing a unit of fertilizer, using the different feedstocks. The Committee, as indicated earlier, tried to identify the optimal level of use of different feedstocks in the economy keeping in view the refinery capacities and the demand for different oil products. The exercises using a programming model* indicate that the use of naphtha for fertilizer production will not lead to overall economy. Fuel oil becomes the preferred feedstock as long as the price of crude is around $7 per barrel. If current prices of coal and crude are considered, coal is indicated as the prefered feedstock for fertilizer production. If the fuel oil production in the refineries is in excess of the demand for fuel oil needed for energy use, it should be subjected to secondary processing to get more of middle distillates products like diesel or kerosene.

*See para 8.

But the discussions with the Government agencies dealing with fertilizer production indicated that the technology for coal-based fertilizer production has not been tried out on a large scale so far and that they would like to gain operating experience from the three coal based fertilizer plants under construction in the country before new coal based projects are taken up. The construction time for a coal-based fertilizer plant is atleast a year longer than the construction time for a fuel oil-based plant. *The Committee is of the view that even if in view of the lack of operating experience of large scale fertilizer produciton based on coal and the need to complete quickly a few more fertilizer projects within the country to meet the shortage of fertilizer a few projects based on fuel oil are taken up during the Fifth Plan, these projects should have adequate provision to switch over to the use of coal at a later date.* Such a change in feedstock is technically feasible with certain additional investment. *The Committee is also of the view that new fertilizer projects should be designed to make use of coal as the feedstock. However, in the refineries, even when the surplus heavy-end products are subjected to secondary processing, there will be some quantities of heavy residual material (vacuum-bottoms) which cannot be used as a oil product except for burning as a fuel or as feedstock for fertilizer production. Such material should be used as feedstock in preference to their use as fuels.* There would, therefore, be a small proportion of fertilizer units during each Plan period which would be based on the use of "fuel oil" i.e. residual oil in the refineries after producing other oil products; the rest of the fertilizer production may have to be based on natural gas or coal.

Gas utilisation

8.42. The use of natural gas represents only a very small share in the total consumption of commercial energy. But it is noteworthy that very rapid increase has been registered in the last one decade. In 1961 the natural gas production was 170 million cubic meters whereas in 1972 it increased to 927 million cubic meters. Table 8.17 sets out the pattern of utilisation in selected areas.

TABLE 8.17

Production and Statewise Utilization of Natural Gas in India

(million cubic metre)

Year	Production	Utilization										
		Assam				Gujarat (ONGC)						Grand Total
		AOC*	OIL*	Others	Total	UPH	DPH	GSFC	Others	Total		
1961	172	154	14	3	171	..	..	..	..	..		171
1966	803	145	64	46	255	66	51	..	..	117		372
1970	1424	134	55	171	360	85	58	174	..	317		677
1972	1,565	127	164	206	497	125	89	189	27	430		927

NOTE: UPH—Uttaran Power Station.
DPH—Dhuvaran Power Station.
GSFC—Gujarat State.
Fertiliser Co.

*AOC and OIL have been using gas for field operations.

It will be seen that considerable quantities of natural gas are not being utilised now as these are produced in small quantities in a large number of wells. Efforts are now being made to utilize as much as possible of the production. *Recent explorations, inland and on-shore, indicate the possibility of discovering substandard quantities of natural gas. The production of fertilizers, methanol and other chemicals based on natural gas will have to be given preference over the use of natural gas as a mere fuel.* It has not been possible at this stage to assess the likely level of production of natural gas in the coming years.

CHAPTER IX

POLICY FOR POWER SECTOR

9.1. Electricity is an important constituent of commercial energy consumed in India. Due to the versatility of its use the rate of growth of consumption of electricity in this country has been the highest among the growth rates of consumption for the various fuels. As electricity can be produced from different sources, namely, coal, oil, nuclear fuels or hydel potential, the choice of technology for production of electricity will have an effect on the demand for other fuels in the country. The choice of technology for power generation will depend on a number of complex techno-economic factors which would be discussed later in the Chapter.

Trend in power consumption and generation

9.2. The generation of electricity from 1960-61 to 1971-72 and the projected level of demand in 1978-79, 1983-84 and 1990-91 are set out in Table 9.1.

TABLE 9.1

Electricity Generation—1960-61 *to* 1990-91

(in million KWhrs)

1960-61	20123
1965-66	36825
1971-72	66384
1978-79 (Projected)	124000
1983-84 (Projected)	205000
1990-91 (Projected)	392000

Indices of Fuel Consumption

9.3. The indices of consumption of diffferent fuels is given in Table 9.2.

TABLE 9.2

Indices of Consumption of coal, oil & electricity

(1960-61=100)

Year	Coal	Oil*	Electricity
1960-61	100	100	100
1965-66	128	159	181
1970-71	127	245	288
1973-74	199	316	355
1978-79	341	478	618
1983-84	505	632	1023
1990-91	847	990	1968

Note: *This includes oil products used in the non-energy sector,

9.4. In Chapter II, the relative rates of growth in consumption of electricity and other fuels have been discussed. The average annual rate of growth of generation of electricity during 1953-54 to 1960-61 was 10.7 per cent while from 1960-61 to 1965-66 it was 12.85 per cent but from 1965-66 to 1971-72 it was 10.35 per cent. In the period after 1971-72 there were severe physical constraints on power generation and its rate of growth in 1972-73 was about 5 per cent. Our forecasts imply that during the Fifth and the Sixth Plan period and upto 1983-84 the average annual growth rate of electricity generation would be 10.7 per cent. The figures obtained by different methods of forecasting indicated a decreasing trend in the annual rate of power requirements over time. But in keeping with the policy of restricting the use of oil products, the Committee felt that electricity generation requirements should be suitably increased so as to provide for the assumed increased consumption of electricity in place of oil in transport, agriculture and domestic sectors.

9.5. The levels of power generation forecast in this Report is capable of fulfilling the following targets of power consumption:

—by 1990-91 all urban households and 70 per cent of rural households in the country will be provided with electricity for lighting purposes;

—the number of agricultural pumpsets operated by electricity will increase from 2.5 million in 1973-74 to about 12 million by 1990-91;

—the per capita consumption would increase on an annual average rate of 9.0 per cent during the period 1973-74 to 1990-91 and reach a level of 447 kWh in 1990-91.

9.6. The per capita consumption of electricity in India from 1960-61 to 1990-91 are set out in Table 9.3.

TABLE 9.3

Per Capita Consumption of Electricity (1960-61 *to* 1990-91)

Year	Per capita consumption (kWh)
1960-61	38·2
1965-66	61·83
1970-71	89·76
1973-74	103·22
1978-79	173·40
1983-84	253·00
1990-91	447·00

9.7. Changes in the per capita consumption of electricity are determined by the changes in population and the total electricity available; the latter is closely correlated to gross national product (GNP). The index of ratio of electricity generated to GNP will move closely with the index of GNP. The movement of the indices of electricity generated, GNP and per capita electricity generated in India is given in Table 9.4.

TABLE 9.4

Indices of electricity generated, GNP and per Capita Electricity Generated

(1960-61=100)

Year		Index of electricity generated	Index of GNP	Index of ratio of electricity generated to GNP	Index of per capita electricity generated
1960-61	..	100·0	100·0	100·0	100·0
1965-66	..	183·0	115·0	168·0	168·1
1970-71	..	326·6	144·2	226·5	258·1
1978-79 (projected)	..	616·2	221·3	278·4	385·9
1983-84 (projected)	..	1018·7	296·1	344·0	594·9
1990-91 (projected)	..	1948·0	445·2	437·6	1044·3

9.8. The elasticity of electricity consumption is defined as the ratio of the percentage rate of growth of power consumption to the percentage rate of growth of GNP. Experience of other countries indicates that the elasticity of electricity consumption slowly deceases over time. The past trends in India and the forecast of electricity consumption made in the Report conforms to the experience of other countries. The elasticity of electricity consumption in India is set out in Table 9.5.

TABLE 9.5

Elasticity of Power Consumption

Period		Average growth rate of GNP %	Average growth rate of power consumption%	Elasticity
1960-61 to 1965-66	..	2·8	12·6	4·5
1965-66 to 1970-71	..	4·6	9·7	2·1
1973-74 to 1978-79	..	5·5	11·7	2·1
1978-79 to 1983-84	..	6·0	10·6	1·8
1983-84 to 1990-91	..	6·0	9·8	1·6

Modes of generation

9.9. The extent to which such growth in the level of consumption of electricity would affect the primary fossil fuel industry like coal and oil would depend on the extent of contribution to the power requirement from the hydel and nuclear power stations in the power generating system. The percentage share of power generated in the past and that projected for 1978-79 from different categories of power stations is given in Table 9.6.

TABLE 9.6

Percentage share of electricity generated by different modes of generation

Year		Hydel	Thermal	Nuclear	Total
1951	..	48·82	51·18	..	100
1956	..	44·45	55·55	..	100
1960-61	..	46·27	53·73	..	100
1965-66	..	46·15	53·85	..	100
1970-71	..	45·23	50·44	4·33	100

9.10 From 1951 right upto 1970-71 the hydel stations have been contributing about 45 per cent of energy generated in the power sector. It is only by the end of the Fifth Plan period that the energy contribution from hydel stations is likely to be lower, i.e., about 38.3 per cent of the total power generation. This lowering of contribution of power generation from hydel stations is partly due to the planned shift towards using hydel power stations as peaking stations and partly due to inadequacy of hydel schemes taken up during the previous Plan periods. In the past there was no systematic evaluation of different choices available for power generation for selecting the optimal mode of generation. Wherever hydel potential was easily exploitable hydel stations were set up and thermal stations came up essentially in areas where coal was in abundant supply.

9.11. Table 9.7 gives the category-wise installed capacity in the power sector in India at different points of time.

TABLE 9.7

Installed Capacity—Categorywise

(MW)

Year		Hydel	Thermal		Nuclear	Total
			Coal	Diesel & Gas		
1940	..	469	624	115	..	1206
1951	..	575	1098	163	..	1836
1956	..	1061	1596	228	..	2885
1960-61	..	1917	2436	300	..	4653
1965-66	..	4124	4417	486	..	9027
1970-71	..	6383	7508	398	420*	14709

*DAE reports capacity exclusive of auxiliary consumption as 400 MW.

9.12. This table indicates that during the Plan periods upto 1965-66 the rate of growth of hydel power generating capacity has been higher than that of other modes. From then on, the additions to thermal capacity have been more than the addi-tions to hydel capacity.

9.13. The percentage share of different modes of power generation in the total power system is given in Table 9.8.

TABLE 9.8

Percentage share of different categories of installed power capacity

Year	Hydel	Thermal (including Diesel & Gas)	Nuclear	Total
1940 ..	38·8	61·2	..	100
1951 ..	31·3	68·7	..	100
1956 ..	36·8	63·2	..	100
1960-61 ..	41·2	58·8	..	100
1965-66 ..	45·7	54·3	..	100
1970-71 ..	43·4	53·7	2·9	100

9.14. The Statewise break-up of different modes of power generation would indicate that in many States which are away from coalfields the power system consisted mainly of hydel stations supplemented with a few isolated thermal stations. Over the years, content of thermal generation has increased in these systems also. Statewise installed capacity for generation for selected years given in Table 9.9. illustrates the trend.

TABLE 9.9

Installed capacity in different States—Category-wise (MW)

Name of the State or Union Territory	1960-61			1965-66			1970-71		
	Hydel	Steam	Diesel & Gas	Hydel	Steam	Diesel & Gas	Hydel	Steam	Diesel & Gas
Andhra Pradesh ..	165·2	83·5	20·2	152·9	113·5	32·1	267·9	320·0	20·2
Assam .. —	9·3	—	10·2	45·9	..	113·6	66·7	..	113·0
Bihar	44·0	288·5	18·4	44·0	608·8	19·5	10·0	472·8	16·3
Gujarat	..	280·9	52·4	..	609·6	41·0	..	619·6	77·2
Haryana	..	6·3	4·3	245·7	28·1	6·3	408·5	90·6	4·8
Himachal Pradesh ..	..	..	..	..	..	..	49·0	..	1·7
J. & K.	10·6	1·5	0·9	28·1	1·5	1·5	26·9	7·5	5·9
Kerala	132·5	..	4·8	192·5	..	4·6	546·5	..	1·6
Madhya Pradesh ..	69·0	169·8	28·7	46·0	233·4	26·1	143·5	582·0	1·6
Maharashtra	281·9	443·3	34·4	598·9	653·3	52·4	844·3	1,471·0	14·1
Mysore	178·2	..	12·9	432·0	1·1	22·5	877·5	..	0·6
Nagaland	..	..	..	..	..	0·7	..	..	2·0
Orissa	123·0	5·8	7·5	304·4	5·8	4·8	304·4	258·3	1·5
Punjab	324·7	1·6	9·5	417·4	5·0	10·3	660·7	15·0	4·5
Rajasthan	..	46·3	24·4	156·3	48·5	41·8	326·8	169·2	44·5
Tamil Nadu	415·5	101·5	0·5	906·6	401·5	6·0	1,114·0	851·5	..
West Bengal (Incl. DBC)	67·2	677·0	9·5	67·5	1,211·2	13·5	129·5	2,128·9	15·2
Delhi (U.T.)	..	53·6	22·7	..	91·6	20·8	..	231·0	20·8
Uttar Pradesh ..	92·5	270·8	34·2	477·8	398·2	54·6	606·3	709·8	35·0

NOTE: 1. In the year 1970-71 Maharashtra includes 420 MW of nuclear capacity against steam.

2. The installed capacities of jointly owned projects have been taken according to the share of participating States.

Source: C.W.P.C. General Review—1971-72.

9.15. The relative growth of installed capacity of hydel and thermal power generation in the different regions indicates that the Northern and the Southern regions are more dependent on hydel power whereas the eastern and the western regions rely more on thermal power. The region-wise installed capacity of power generation and the energy generated from hydel and thermal power stations in different years are given in Table 9.10.

TABLE 9.10

Regionwise growth of installed capacity and energy generated from hydel and thermal power stations

Year	Capacity in MW			Generation in million KWH		
	Hydel	Thermal	Total	Hydel	Thermal	Total
			ALL-INDIA			
1950-51	559	1,004	1,712	2,360	2,779	5,858
1960-61	1,911	2,436	4,653	8,738	8,732	16,987
1965-66	4,124	4,551	9,027	17,441	32,990	32,990
1970-71	6,383	7,667	14,709	25,206	28,864	56,604
			NORTHERN REGION			
1950-51	52	56	147	188	180	411
1960-61	335	108	507	1,022	348	1,432
1965-66	847	186	1,104	3,497	536	4,084
1970-71	1,472	513	2,078	5,124	1,822	6,981
			SOUTHERN REGION			
1950-51	238	98	362	1,256	320	1,500
1960-61	891	186	1,176	4,168	562	4,749
1965-66	1,684	546	2,266	5,499	2,742	8,261
1970-71	2,806	1,192	400	11,435	4,030	15,465
			WESTERN REGION			
1950-51	253	201	620	1,229	653	1,987
1960-61	351	984	1,362	1,388	3,474	5,016
1965-66	654	1,502	2,266	3,236	5,681	9,051
1970-71	987	2,307	3,753	5,003	8,633	16,064
			EASTERN REGION			
1950-51	3	851	598	6	1,318	1,346
1960-61	234	972	1,241	788	3,559	4,407
1965-66	416	1,826	2,279	1,426	6,960	8,426
1970-71	..	..	..	..	..	..
			NORTH-EASTERN REGION			
1950-51	0·6	..	3·4	2	2	9
1960-61	9·3	..	10·2	21	..	36
1965-66	45·9	81·5	32·1	58	15	96
1970-71	66·7	81·5	38·0	158	194	3,377

Power generation and installed capacity

9.16. The data of installed capacity and power generated from each mode have been examined with a view to determine the possible levels of supply from the different modes of power generation in future, the possible improvements in operational efficiencies so as to arrive at some broad conclusions regarding the total installed capacity that would be necessary to adequately supply the projected electricity demands at different points of time in future. The Committee adopted the procedure of estimating the future capacity needs of the power industry from the forecast of energy requirements. The methods adopted for forecasting the consumption requirements of energy have been described in Chapter III. The consumption requirements of electricity have been converted into generation requirements by adding the extra power required for auxiliary consumption and to provide transmission losses. The power generation requirements are converted to capacity requirements by studying the past relationship between generation and installed capacity.

Auxiliary consumption

9.17. A power generating station requires power for consumption in the station itself which is referred to as auxiliary consumption. This is normally around 8 per cent in thermal stations and a little less than 1 per cent in hydel stations. On the basis of the mix of hydel and thermal, in the different periods, assumed in our forecasts in Chapter III, the auxiliary consumption requirements have been estimated to be as 6.2 per cent of the total generation during the Fifth Plan period and about 5.6 per cent in the subsequent periods.

9.18. In a power system, the difference in the units despatched from the generating station and the units sold to the consumers is referred to as the energy losses in the system. This loss consists of two components (i) the energy dissipated of the system due to the inherent characteristics of the equipment and conductors used for transmitting and distributing power (i.e., loss due to technical reasons) and (ii) commercial losses or unaccountable losses due to pilferage, inaccurate meter readings and computations etc. We shall refer to the former as electricity "Dissipation" and the latter as electricity "Losses". The magnitude of the "Dissipation" depends largely on the area served by the system, the pattern of loading of transmission lines, types of loads and the planning and designing of the generation and transmission system. The "Losses" depend on the efficiency of administration of the power system.

9.19. A comparison of energy dissipation and losses (total losses) in power system in India with other countries indicates that the total energy losses in India are high as compared to other industrially advanced countries.

Table 9.11 shows the percentage of transmission and distribution energy losses during the year 1967 and 1968 in the power systems of certain European countries and India.

TABLE 9.11

Percentage of total transmission and distribution losses in various countries during 1967 and 1968.

Serial No.	Country	Total Transmission & Distribution Energy Losses (Percent) 1967	1968
1	Austria	9·6	9·9
2	Czechoslovakia	7·8	8·1
3	Finland	8·3	7·7
4	France	7·6	7·4
5	Hungary	9·3	10·3
6	Ireland	11·2	10·6
7	Italy	10·1	9·1
8	Norway	10·4	10·2
9	Poland	8·7	8·6
10	Sweden	12·1	12·5
11	Switzerland	8·2	8·1
12	West Germany	5·9	5·7
13	Yugoslavia	11·9	11·1
14	India	15·0	16·7

The percentage of total losses varies from 5.7 per cent in West Germany to 12.5 per cent in Sweden. As compared to this the total losses in India during the years 1967-68 and 1968-69 were 15.04 and 16.7 per cent respectively. In 1970-71 the total losses were estimated to be 17.3 per cent in India.

9.20. If the total losses in India were maintained in 1970-71 at the level of 1967 (i.e. 15 per cent) the savings in energy would have been nearly 1.500 million kWh and the savings in cost of power generation nearly Rs. 9 crores annually. The reduction in total energy losses would have reduced the required installed capacity for power generation, fuel consumption etc. Based on the figures of 1970-71, there could have been a saving of about Rs. 60 crores in the investment costs, if the level of total power losses had been maintained at 15 per cent.

9.21. It is noteworthy that several countries which had experienced large total losses in their power distribution and transmission system have taken successful measures to reduce the extent of losses. For example, the percentage of 'total losses' in Japan was 30 per cent in 1945, but the figure has now been reduced to 11 per cent by

constant efforts. Another example is Taiwan where losses have been reduced from 21.7 per cent to 13.6 per cent in 1960*.

9.22. It is to be recognised that a major portion of the total losses is "Dissipation" arising out of technical reasons and the reduction in such dissipation can be effected only by a proper planning of the power system. In India the total loss varies widely from State to State. Table 9.12 represents the total losses (dissipation and losses) as percentage of energy available for transmission in each State of India for the years 1961-62, 1965-66 and 1970-71. It would be seen that the States of Andhra Pradesh, Bihar, Haryana, Jammu and Kashmir, Nagaland, Punjab, Tamil Nadu and Uttar Pradesh have particularly higher percentage of total power losses.

TABLE 9.12

Losses in transmission, transformation, distribution and energy unaccounted for expressed as percentage of energy available for transmission

State	1961-62	1965-66	1970-71
1. Andhra Pradesh	26·35	24·71	24·77
2. Assam	18·24	23·61	17·87
3. Bihar	23·49	11·56	23·58
4. Gujarat	10·44	11·51	16·59
5. Jammu & Kashmir ..	15·45	..	21·49
6. Haryana	..	..	27·89
7. Kerala	15·81	20·06	12·17
8. Madhya Pradesh	11·83	11·75	14·35
9. Maharashtra	9·95	12·00	13·10
10. Mysore	13·83	16·34	14·28
11. Nagaland	..	15·88	20·34
12. Orissa	15·32	14·60	5·48
13. Punjab	13·58	14·59	35·46
14. Rajasthan	19·43	20·06	11·91
15. Tamil Nadu	19·28	17·52	17·21
16. Uttar Pradesh	15·34	18·60	23·63
17. West Bengal	9·55	8·60	8·30
ALL INDIA	14·44	14·02	17·30

SOURCE : General Reviews CW & PC

9.23. The reasons for high dissipation of energy are mainly due to inadequacy of transmission and distribution lines, large proportion of agricultural loads, supplying power to areas located far from the generating sources, low power factor, etc. This "Dissipation" of energy can be controlled through certain measures such as careful scheduling of the reactive generation, integrated operation of various power systems, provision of adequate quantity of transmission lines and selection of right designs for transmission and distri bution lines. "Losses" (unaccounted for) are mainly due to unauthorised tapping of energy and these could be reduced by stricter administrative measures.

9.24. In order to reduce the percentage of total losses an in-depth study was conducted by the Power Economy Committee and certain measures for reducing the total Losses as outlined above, were recommended. This Committee would like to endorse these recommendations and suggest that systematic study of the causes of transmission losses in different regions and States should be undertaken and remedial measures taken to completely eliminate the losses due to administrative reasons and reduce the "Dissipation" to the level that is technologically determined.

9.25. In our projections of power generation we have assumed that the total power losses would be reduced to 13.8 per cent by 1978-79 and to 13.4 per cent by 1983-84 and thereafter. Considering that in the first half of the Sixties, the power losses were only 14 per cent to 14.5 per cent, this assumption regarding the losses during the Fifth Five Year Plan appears very reasonable. In the period after 1978-79, if there are large number of pithead generating stations, energy "Dissipation" at the transmission stage may increase but improved and rationalised distribution system that may be set up will help in reducing the "Dissipation" at the distribution level; "Losses" can be brought down by better administration of the power system. The Committee has, therefore, assumed that the total power loss could be brought down to 13.4 per cent by 1983-84.

Electricity generation capacity

9.26. The primary purpose of forecasting electricity demand is to initiate action for setting up the required additional capacity for generating electricity to meet the expected incremental demand. There is, therefore, need to have reliable procedures for converting the demand forecast of electric energy into the required power generation capacity. If the structure of load at the different centres of demand at different points of time in future is known it would be possible to work out the required capacity and the mix of different modes of generation simultaneously. In the absence of reliable forecast of load at different centres, the required generation capacity is usually determined on the basis of the past relationship between energy demand and installed capacity.

9.27. The normal procedure is to first estimate the peak load demand consistent with the energy requirements by applying estimated load factors. The load factor represents the amount of energy in kWh required per kW of peak load and it is usually expressed as a percentage of the total number of hours in a year i.e. 8760.

$$\%\text{Load Factor} = \frac{\text{Energy Requirements (kWh)}}{\text{Peak Load (kW)} \times 8760} \times 100$$

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Load factor would depend on a number of factors like the mix of different consumer categories served by the power system and also the habits and conventions of the people, weather conditions, etc. While some of these factors are beyond the control of the power authorities, some adjustments in the load factor could be effected by a rational system of regulating power supply and pricing of power (See Chapter XI). A load factor of 60 per cent for the total system has been achieved in India in most years (See Table 9.13). The decline in the load factor from 1968-69 onwards is a disturbing trend. It is true that the sharp increases in the share of supplies effected to agricultural loads and rural area demands would tend to increased variations in the demand during different hours of the day and various seasons of the year and thus affect the system load factor. On the other hand, better inter-connection of generating systems in each State and inter-connection of different State-grids should lead to a great level of coordination in the operation of different power systems and increase the system load factor. Effects of these two developments should at least off set each other and maintain the system load factor at 60 per cent. Energy Survey Committee (1965) had suggested that the load factor should be 60 per cent in the Seventies and a little higher in later years. Taking all the facts into account, the Committee has assumed that the load factor in India would be 60 per cent upto 1978-79 and 65 per cent thereafter. Peak load at different points of time have to be calculated on this basis.

9.28. The power system should have adequate installed capacity to serve the anticipated peak load. The ratio of peak load to peak capability is referred to as the Demand Factor.

$$\text{Demand Factor} = \frac{\text{Peak Load (KW)}}{\text{Peak Capability (kW)}}$$

In India the demand factor for the entire power system has varied from 75 per cent to 85 per cent in the past as set out in Table 9.13*. Energy Survey Committee (1965) had suggested that the demand factor should be 80 per cent. In other words, the gross margin (of installed capacity) over the peak load should be 25 per cent of the peak load. The gross margin in a power system should be of sufficient magnitude to provide for scheduled maintenance, emergency outages and system operating requirements. The gross margin obviously would depend upon the size of the system, the hydro-thermal mix of generating plants in the system, the size of the largest set in the system, forced outages of different generating sets, the characteristics of the load which is supplied from the system, the extent of coordination available with other power systems and the expected reliability postulated for the system. A proper determination of the gross margin requirements would involve a detailed system study of each power system in the country. So far no such studies have been made†. But, past experience shows that under different conditions, the gross margin of 25 per cent over the peak has been achieved and such margin enabled the system to service the demand without significant load shedding. We, therefore, assume that upto the end of the Fifth Plan, the demand factor would be 0.8.

9.29. In later years, the inter-connection between the system would tend to increase the demand factor; but the introduction of larger unit size plants in relation to total system capacity would tend to decrease the demand factor. It has, therefore, been assumed that the demand factor may continue to be 0.8 right upto 1990-91. The plant factor which is defined as the multiple of load and demand factors would be around 48 per cent during the Fifth Plan period. As a result of the increase in the load factor to around 65 per cent in the subsequent periods, it is assumed that the plant factor would be 51 per cent in the years beyond 1978-79. This is in agreement with the suggestions made by the Energy Survey Committee in 1965‡ that the plant factor should be around 48 per cent during the Fourth Plan period (upto 1970-71) and 51 per cent beyond that period.

9.30. These assumptions also appear to be very reasonable as seen from the past data.

TABLE 9.13

Load factor, demand factor and plant factor of the power system in India

Year	Load factor	Demand factor	Plant factor
1955-56	0·656	0·756	0·496
1960-61	0·584	0·854	0·499
1965-66	0·672	0·742	0·499
1970-71	0·637	0·828	0·527
1973-74 (likely) ..	0·595	0·902	0·537

9.31. The installed capacity of power generation may not be the same as system peak capability; installed capacity represents the total of the name plate rating of the units set up at different points of time in the past. Their capacity rating would diminish over time. The power capacity of hydel stations vary with the seasons due to changes in storage level and seasonal flows. The full power capability of the hydel stations may not occur at the time when the annual peak load occurs. This leads to the maximum system capability being less than their 'Norms' or name

*In the Years 1972-73 to 1973-74, the demand factor has increased but these years also witnessed widespread and frequent load sheddings and as such should not be considered as a basis for forecasting the demand factor in future years.

†The committee attempted to organise studies in this regard which had to abandon d for want of data.

‡Report of the Energy Survey Committee, page 174.

plate rating. The Power Survey Committee which does the annual forecasting of power determines the power capability of each of the power stations and sums up the total as system peak capability. This has been varying from 85 per cent to 93 per cent of the installed capacity in the different regions. With rapid increase in the thermal capacity, the system peak capability as a percentage of installed capacity should increase. Considering all the factors, a 90 per cent of the installed capacity can be assumed as system peak capability during the Fifth Plan period; after the Fifth Plan this percentage will increase as a large number of old thermal sets would be retired by the end of the Fifth Plan and as hydel power stations would be designed to meet specific load patterns. It has, therefore, been assumed that in the period beyond 1978-79, 95 per cent of the installed capacity would represent peak capability.

9.32. The installed capacity requirements for different years in future to meet the energy requirements corresponding to the Case II estimates projected in Chapter III of this Report have been computed in Table 9.14.

TABLE 9.14

Installed capacity requirements for power generation in 1978-79, 1983-84 *and* 1990-91

Year			Forecast of Energy Consumption (b kWh)	Forecast of Energy Requirement* (b kWh)	Installed capacity needed (million kW)
1978-79	..	..	100·3	116·4	33·6
1983-84	..	..	167·7	193·6	53·0
1990-91	..	..	320·4	370·7	87·3

*At the bus-bar, i.e., consumption plus line losses.

NOTES

(1) On the basis of the calculations for 0·48 plant factor and 90 per cent availability the installed capacity required in the year 1978-79 would be 30·7 million kW. However, as there is a large spillover of works from the Fourth Plan and due to bunching of new projects the capacity coming on stream into the final year of the Fifth Plan is very large. But as many of them would be operative only in the second half of the final year, only half of the benefits have been counted towards the Fifth Plan and hence the increased provision of installed capacity.

(2) For the year 1983-84, on the basis of 0·495 plant factory and 92 per cent availability the installed capacity should be 48 5 million kW. This is, however, being assumed as 53·0 million kW for reasons which are similar as in the case of 1978.79.

(3) The figure of installed capacity has been arrived at 87.3 million kW on the basis of 0·51 plant factor and 95 per cent availability.

9.33. In the above table somewhat higher estimates of installed capacity for the years 1978-79 and 1983-84 have been assumed. This is because the efficiency in operation etc. would be gradually achieved over a period of time. However, it is necessary to take effective measures to improve the plant factor in the Indian power system at least from the Sixth Plan period and thereafter. Such improvements have a significant effect on the investment requirements for the power sector and consequently on the cost of power to consumers. With an improvement of 1 per cent in the plant factor in the Fifth Plan, there could be a saving of Rs. 163 crores. It appears possible to improve the plant factor beyond 51 per cent also, if proper measures are taken; the minimum performance expected in 1983-84 and 1990-91 should be 51 per cent plant factor. *The Committee would strongly recommend that rational measures should be initiated in planning and operating the power systems so as to ensure gradual improvement in the plant factor.*

9.34. It is also possible to improve the load factor by influencing changes in the structures of load that faces a power system. If the difference between the peak load demand and the off-peak load demand is reduced, the load factor of the power system would improve. In several countries, this reduction in the difference between the peak load and the off-peak demand is being achieved by offering differential rates to consumers with reference to the time at which they consume power. In countries like France and U.K. efforts to develop off-peak load by supplying power at reduced price (usually on marginal pricing) during off-peak hours have yielded good dividends. In U.K. the electricity supply authorities devote greater attention to load development measures.

9.35. *The Committee recommends that during the Fifth Plan period efforts should be made to develop a more optimal load structure*:

1. *by setting up more pumped storage schemes wherever such schemes would improve the system capability at minimum cost.*

2. *by indentifying industries which are intensive users of electricity and are also capable of organizing their production schedule in such a way that their peak demand would occur during the system off-peak period and by giving to such units adequate incentive through specially designed tariff to encourage them to reorganise their production;*

3. *by general pricing of the industrial tariff and agriculture tariff to provide incentive for use of more electricity during off-peak hours.*

9.36. In the Chapter in 'Cost and Prices' certain aspects of a rational pricing policy in the power sector have been discussed.

Growth of peak load

9.37. On the basis of our projections, the connecting peak load that can be reliably serviced by the power system in India at different points of time are as follows:

1978-79	22.1. million kW
1983-84	35.7 million kW
1990-91	66.4 million kW

The likely peak load in the year 1973-74 is estimated to be 13.66 million kW. This will provide for an average annual growth rate of 10.20 per cent in the Fifth Plan, 10.10 per cent in the Sixth Plan and 9.30 per cent in the subsequent periods. It is worthwhile to note that the average rate of peak load growth in the past i.e., from 1960-61 to 1965-66 and from 1965-66 to 1970-71 has been 11.1 per cent and 11.8 per cent respectively.

Selection of the mode of generation

9.38. Electricity could be generated using coal or lignite as fuel in the thermal stations or by utilizing the hydro electric power potential or by using fissile material in the nuclear plant. Each of these modes of generation has certain characteristics in terms of their capability to supply power energy, they also have widely varying investment and operating costs. The thermal plants have a high investment cost as well as a high operating cost but they are capable of giving a steady stream of power for long periods at a stretch. They are ideal for use as base load power stations. The hydel plants have high investment costs but very low operating costs. They can be switched on and off at short intervals but the total energy potential would depend on the hydrological environment. Hydel stations (the reservoir type stations) are best used as peaking stations to meet the power demand during the peak hours of the day. The run of the river hydel stations have very low operating costs and sometime very low investment costs, but large variations in the seasonal flow of water in the river lead to the energy contribution varying with the season. The nuclear plants have a very high investment cost and useful only as base load stations as they are economical only when operated at a load factor of over 75 per cent. The selection of the mix of thermal, hydel and nuclear stations that could be set up to adequately meet a given structure of demand for electricity could be done rationally only by investment planning exercises using programming models. There are no officially sponsored studies so far for any region or any State based on such investment planning exercises. The Fuel Policy Committee attempted some exercises but were unable to complete the work for want of reliable data of the characteristics of the hydel stations and the structural and spatial disposition of power demand.

9.39. Even in the absence of such studies, it is possible to make a comparative evaluation of the choice to be made between hydel and thermal stations in the circumstances in India today. Data on the relative costs of hydel and thermal stations are discussed in Chapter XI. It is clear that as of today, hydel stations are more economical than any other source of electricity at low load factors. Supplying the peak load involves the generating stations operating at low load factors of even 30 per cent and below. In such conditions, hydel power is the best way of meeting the demand. The fact that hydro resources constitute the cheapest source of electricity production under present conditions has been emphasised by several Technical Committees. The Energy Survey Committee in their Report in 1965 had concluded "that storage hydel is the cheapest method of generating electricity in the conditions for which it is most suited, so long as most favourable sites can be discovered"(‡ and recommended that "it seems clear that India will be well advised to explore hydel resources wherever there are suitable sites available". The Power Economy Committee (1971) have brought out succinctly the loss in our economy by not following the admittedly more economic path of lowest cost development and observed "our aim is to create the maximum amount of generating capacity with the funds available and to generate power at as cheap a rate as possible. *To achieve these objectives, it is recommended that during the Fifth and Sixth Plans the level of new generating capacity to be added should be derived from hydro stations, both of the energy intensive and peaking categories*".

9.40. This Committee in the earlier Report on the 'Fuel Policy for the Seventies' had emphasised the need for giving high priority for hydel power development even during the Fifth Plan consistent with the need to supply adequate power to meet the demand in this period. The Committee is concerned that the target dates for completion of hydel stations under construction as indicated in 1972 are now reported to have receded due to a number of reasons. *The Committee would urge that during the Fifth Plan, a very strong effort should be made to complete as many as possible of the hydel stations under construction. This would improve the power availability and reduce the total system cost of power generation during the Fifth Plan. During the Sixth Plan and thereafter if hydel power is not adequately developed, it would become very difficult to meet the electricity requirements.*

9.41. In Chapter V, the region-wise distribution of hydro resources and their classification into potential storage projects and potential run-of-the-river projects have been dicussed. It is seen that except in the eastern region, other regions

(1) Energy Survey Committee page 132, para 349.

have very large hydro potential which remains un-utilised.

TABLE 9.15

Regionwise distribution of hydro electric resources and utilization by end of Fifth Plan

Region		Total Resources at 60% L.F. (MW)	Resources planned to be utilised by 1976-79	Percentage of utilization by 1968-79
Southern	..	8097	6785	83·77
Western	..	7169	2315	32·29
Northern	..	10731	5700	55·12
Eastern	..	2694	1395	53·78
North-Eastern	..	12464	392	3·15
Total	..	41155	16585	40·30

During 1990's, there is a possibility of greater contribution from nuclear sources. Till 1990-91, thermal and hydel power stations would contribute the major share of power capacity. Harnessing of hydel power should be given priority and by 1990-91 at least 70—80 per cent of the total known hydel potential in the country should be developed. In terms of regions it may mean about 50—60 per cent of the potential being used in the North-Eastern region and about 80—90 per cent being used in the other four regions. In our calculations of coal requirements, we have assumed the contribution of hydel power to total power generation to the extent of 35 per cent in 1983-84 as well as in 1990-91. To maintain the share of hydel power at about 33 per cent of total power generation in 1990-91 as compared to 43 per cent in 1973-74, about 70—80 per cent of the total hydel potential will have to be harnessed.

9.42. *The Committee would strongly urge that a detailed investigation of the specific projects which could be set up to utilise the hydro-electric resources should be drawn up within the next two years and the scheduling of different hydro projects should be determined with reference to the cost of the projects, the characteristics of the projects and their locations. On this basis, a detailed hydro-electric power development programme should be drawn up for the future upto* 1990-91 *or even* 2000 *A.D.*

Nuclear power generation

9.43. The capacity of nuclear generation to be set up in the country would depend on the long-term nuclear technological development programme which, in turn, would depend on a number of factors like availability of nucler fissile materials, the advance in nuclear technology and the strategy adopted by the country by nuclear advancement. These are dealt with in a separate section in this Chapter. Briefly, based on the conclusions of the studies discussed therein and the assessment of the pace of construction based on current experience of nuclear power projects *it was felt the capacity of the nuclear power stations could be as follows*:

1978-79	1020 MW
1983-84	1900 MW
1990-91	4600 MW

The Department of Atomic Energy (DAE) has confirmed that their programme for power project construction would agree with our estimates upto 1983-84; but by 1990-91, the DAE have estimated that 8620 MW of nuclear power capacity would be established. This amount to nearly 1000 MW of nuclear capacity being added every year from 1983-84. *The Committee would like to endorse the view of DAE that nuclear power capacity, if possible, should be increased to the maximum extent possible by* 1990-91. It is too early to make a positive assertion on the possible level of nuclear power in 1990-91 and, therefore, *it would recommend that a review of nuclear programme should be made by* 1978-79 *in the light of the pace of construction of nuclear power stations in the Fifth Plan period, the preparedness of the DAE in respect of design for 500 MW nuclear power plants and the progress made by them towards the commercialisation of the Fast Breeder technology.* (See section on Nuclear Power in this Chapter covering the nuclear power programme).

9.44. The capacity requirements in different areas and the contribution from different sources of different modes of power generation have been calculated and given in the Table below. In these calcuations, all hydel and thermal stations have also been calculated on roughly 60 per cent load factor. In reality, the relative share of installed capacity between hydel and thermal will vary, usually hydel stations being higher and thermal stations being lower as the load factor of operation of the hydel stations would be much less than 60 per cent whereas that of thermal stations higher than 60 per cent. It will not be possible at this stage to work out the actual capacities of the hydel stations till the investigations and project reports for hydro-electric projects are completed.

TABLE 9.16

Installed capactiy categorywise for power generation (1978-79, 1983-84 *and* 1990-91)

Year/Mode of Generation			1978-79	1983-84	1990-91
Hydel	..	..	13·00	20·00	28·40
Nuclear	..	..	1·02	1·90	8·62
Thermal	..	..	19·55	31·10	50·30
Total		..	33·57	53·00	87·32

NOTE: Thermal Stations include coal and lignite based pow stations.

Choice of size of generating units

9.45. It is clear from the demand forecast of electricity that the requirement of electricity will increase so fast that the power supply in the country has to undergo big modernization and change. In the place of small power generating units of 30 MW and 60 MW there will be need for including very large size of generating units.

The factors which favour the adoption of large generating units are:

—The lower capital cost and lower operating cost due to higher efficiencies in heat utilization;

—Reduction in the number of construction and maintenance crews; a category of skills which are in short supply in the country.

The factors which discourage the large units are—

— Increased forced outage rate due to high pressure and high temperature at which large size units function;

— Increase in transmission system cost.

9.46. Selection of appropriate generating size should, therefore, be done taking into account not only the economics of skills of the individual power station level, but also with due regard to system stability considerations. The economics in investment and operating costs due to increase in size are admitted by all, though there are divergent views regarding the measurement of the economics.

9.47. In the current situation in India, the cost for different sizes of thermal plants are given at Table 9.17.

TABLE 9.17

**Table showing investment and operating costs of thermal plants of different sizes*

	100 MW	200 MW	500 MW
Cost per kW installed Rs. ..	1,800	1,500	1,300
Operation and maintenance charges per kW installed Rs. ..	31·50	26·25	22·75

* Based on 1970 data, the relative costs may still remain the same.

The selection of size of plant for a thermal station has also a significant effect in the quantity of fuel that would be required for power generation as the large size plant consumes lesser coal per kWh of power to be generated. Assuming a calorific value of coal as the fuel requirement per kWh for different sizes of plant are summarised in Table 9.18.

TABLE 9.18

Fuel requirement for different sizes of plant

	100 MW	200 MW	500 MW
Coal requirement per kWh (of energy generated) (kg) ..	0·60	0·53	0·50

It is interesting to note that there could be a saving to the tune of about Rs. 60 lakhs per annum on account of cost of fuel only if two sets of 500 MW each were adopted instead of 5 sets of 200 MW each for a 1000 MW thermal power station operating at 60 per cent plant factor (assuming a coal price of Rs. 40.00 per tonne). However, the selection of plant cannot be made purely with reference to the economics available at the plant level.

A wide range of factors have to be taken into account as follows:—

1—The present size of power system.

2—The energy sources, i.e., hydro, thermal or nuclear plant, in the system.

3—The level of reliability expected from the system.

4—The transmission grid in operation.

5—The pattenr of growth of power and energy demands.

6—The forced outages of the generating plants of different sizes.

7—The gestation lags in commissioning plants of different sizes.

8—The comparative investment in operating and maintenance of plants of different sizes.

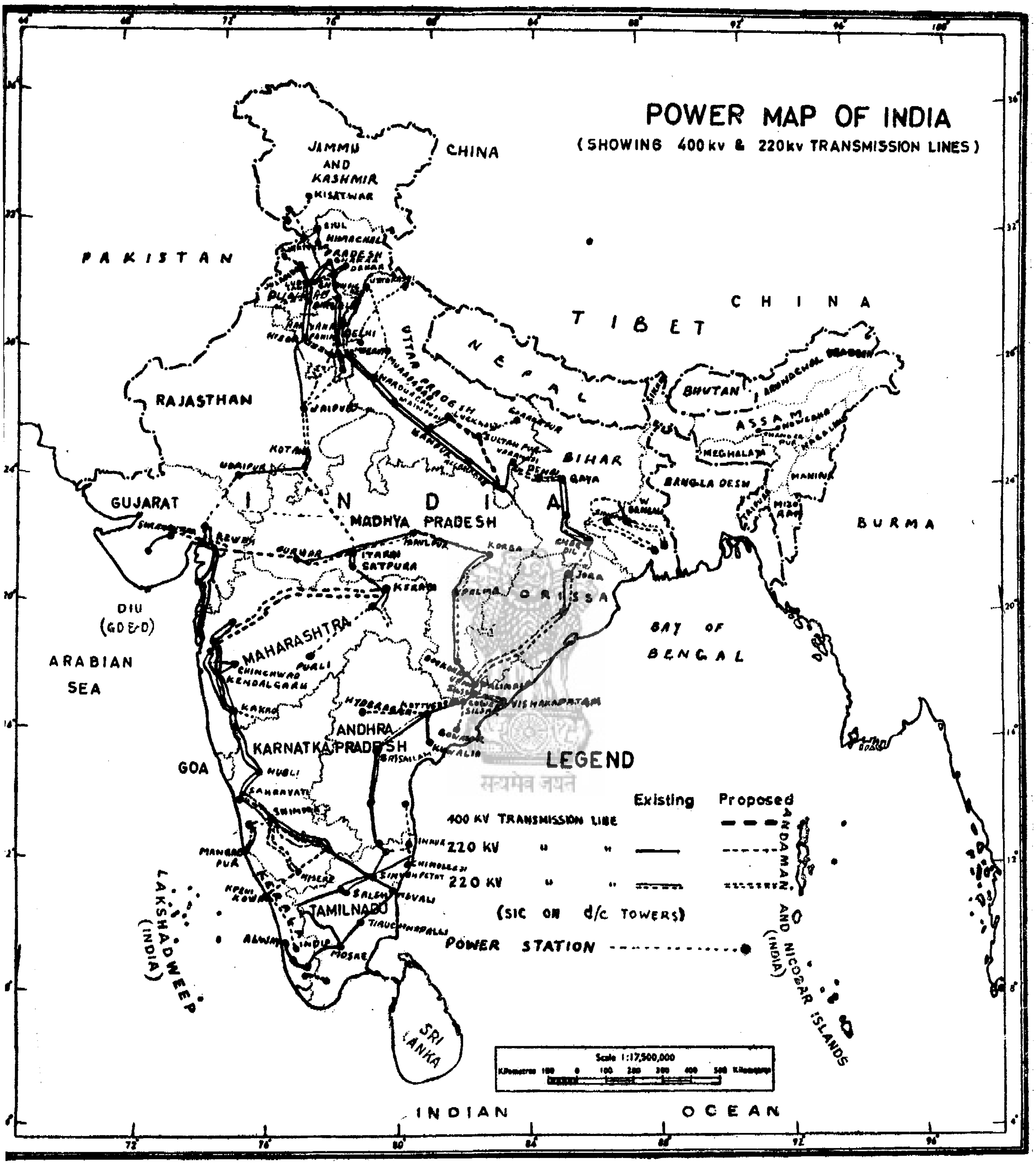
9—The manufacturing capacity of the electric supply industry.

10—The possibility of transporting the equipment of specific sizes and weights to the different parts of the country.

11—The additional transmission investment.

All these factors could be taken note of only by elaborate system studies. *The Committee would recommend that immediately such studies should be undertaken to determine the optimal plant size for different regions of the country.*

9.48. In the absence of studies, the Committee tried to determine the unit sizes that could be introduced in the power system in India by getting opinion from people who are closely associated with planning and operation of power systems. It is generally felt that 500 MW stations could be introduced only after the regional grids are in full operation by proper integration of the power generation systems of various States in each region. As the construction of the required transmission lines and evolution of operational techniques are yet to be completed, the introduction of 500 MW sets will be possible only in the eighties but *during Fifth Plan period, the design capability should be developed and operational norms for a 500 MW set should be studied by setting up an R&D plant of 500 MW capacity.* The Committee agrees with this recommendation.



ased upon Survey of India map with the permission of the Surveyor General of India

he territorial waters of India extend into the sea to a distance of twelve nautical iles measured from the appropriate base line.

he boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas leorganisation) Act, 1971, but has yet to be verified.

Choice of location of power plants

9.49. In addition to the choice of type of power stations, the location of the power stations is also very important. Considering the requirements of power in the near future, the size of thermal power stations will have to be necessarily relatively big, of the order of 1000 MW each. Stations of this magnitude will need about 3-4 million tonnes of coal per annum. Movement of such large quantities of coal in the context of the difficulties we are experiencing even now for the movement of comparatively small quantities of coal to power stations from the pit-heads would pose formidable operational problems including that of heavy investment on the railway system. Moreover, since the available reserves of good quality coal are severely limited, power generation will necessarily have to be based on inferior quality coal with relatively high ash content and low calorific value. The ash content of our coals and of the middlings that may have to be used may be of the order of 35—40 per cent. This would mean additional load on the rail transport. Several studies have been carried out to investigate the relative economics of power generation at load centres vis-a-vis at pitheads. These investigations show that for a 1000 MW plant, even when it is assumed that the railway operations would improve significantly and that the movement of coal to the load centres will be carried out on unit train basis, the pithead generation and transmission of power to load centres is still slightly more economical than to transportation of coal to power plants at load centres. Furthermore, location of power stations of this dimension at load centres which may be densely populated will expose a large number of people to pollution. *The Committee, therefore, feels that in the overall interest of the economy and environmental considerations, more and more of such power stations should be located at pit-heads. Depending on the local conditions, however, construction of power stations at load centres can be considered on merits as a special case.*

Transmission and load despatching stations

9.50. In any power generation and distribution organization, the maximum economies are attained only by the proper designing of the power system and by the integrated operation of the system as a whole. As power requirements of each consumer of power vary at each moment of time, the integrated operation enables the diverse needs to be met at the lowest cost. Proper connection of different generating systems and the generating stations with load centres through a rationally designed transmission system capable of meeting the transmission requirements fully is as important as having adequate generating capacity. The recent trippings in the transmission systems at different places in the country have brought out the urgency for more attention to be paid to transmission system.

9.51. The investments in transmission in the country appear to be inadequate to ensure proper distribution of power and rational operation of the generating system. Even in the early years of the Fifth Plan when there will be some localised shortages of power, there will be power stations which cannot be operated at full load due to lack of transmission facilities.

9.52. There are enormous advantages in rationally designing a transmission system keeping in view the demand over time at different points of consumption. In other countries, extra high voltage transmission already in operation and bulk transfer of power through D.C. transmission lines is also being practised. In our country, the first 400 kv line will come into operation in Uttar Pradesh in the year 1975-76. There is need for greater attention being paid to transmission planning and operation of transmission lines.

9.53. The great advantages of the large electricity system could be fully reaped only if there is an integrated operation of all the generating stations. At the moment, the State Electricity Boards are the owners of the generating stations and the generation optimization is being done strictly with reference to the stations within the control of each Electricity Board. Some measures towards regional operation have been introduced in the Southern Zone with the setting up of the Load Despatch Centre, under the auspices of the Southern Regional Electricity Board. The Government have accepted, in principle, the scheme of integrating the operations of the Electricity Board in each region. Load despatch stations have been proposed in each region and the hardware required for the same are being procured. But important questions relating to integrated operation like the conditions under which inter-State power flows could be charged on a continuous basis and the procedures for sharing shortages etc., have still to be worked out.

9.54. *The Committee would very strongly urge that the schemes for setting up of regional grids and regional load despatch centres should be vigorously pursued; simultaneously procedures for the integrated planning and operation of power systems based on system studies should be introduced.*

Rural Electrification

9.55. Electrification of a village not only adds to the productive capacities of the farmers but also brings with it social, civil and domestic amenities and has a salutary psychological effect on the rural people who start having a feel of the modern age. Its availability stimulates the growth and expansion of agro-based small and medium scale rural crafts and industries like pottery, weaving, wood work, rice, flour and oil

mills, could storages and packing industries etc. It also helps to substitute kerosene oil which is used for illumination, by electricity. But the primary justification of rural electrification is to help the production efforts in the agricultural sector.

9.56. Presently, out of the total geographical area of 327 million hectares about 158 hectares of land is under cultivation. But the output is low due to inadequate availability of irrigation facilities. The erratic character of Indian monsoon very seriously affects agricultural production and creates large uncertainties regarding India's economic growth. Provision of regular and sufficient supply of water is therefore important. Empirical evidence suggests that the periodic uncertainties that beset surface irrigation sources do not affect the ground water sources in the same intensity. It is here that rural electrification can play an important role by increasing the number of tubewells/pump sets in the country. Table 9.19 gives the conclusions of the Irrigation Commission (1972) regarding the ground water resources available in different State of the country and the extent to which these have been utilized. It is estimated that the txent of the ground water resources now utilised will be only about 40 per cent.

TABLE 9.19

Ground Water Resources

State	Net ground water recharge*	Annual draft by the end of 1967-68*	Net ground water recharge available for future ground water development*.	Area irrigated** by ground water at present (m. acres)
1. Andhra Pradesh ..	17·2	3·57	13·6	1·4
2. Assam Region (incl. Nagaland,NEFA etc)	16·7	0·0 3	16·7	—
3. Bihar	21·9	2·35	19·5	1·2
4. Delhi	0·3	..	..	..
5. Gujarat	10·2	4·13	6·1	..
6. Haryana	3·5	0·75	2·7	..
7. Himachal Pradesh	0·9	n.a.	..	..
8. J & K	4·0	0·001	4·03	0·03
9. Kerala ..	5·4	0·004	5·4	0·016
10. Madhya Pradesh ..	26·7	4·22	22·5	1·00
11. Tamil Nadu and Pondicherry ..	11·5	3·47	8·00	2·30
12. Maharashtra ..	12·6	3·41	9·2	2·00
13. Mysore	10·0	1·03	9·0	0·75
14. Punjab	6·9	3·3	3·6	3·5
15. Orissa	16·0	0·15	15·8	0·20
16. Rajasthan ..	3·4	2·07	1·4	3·00
17. Uttar Pradesh ..	35·5	17·92	17·6	9·00
18. West Bengal ..	16·1	0·36	15·7	0·10
Total ..	218·8	46·738	170·83	24·496

*In million acre feet.

**Distribution on the proportional rate of the total irrigated area.

n.a. Not available

(SOURCE: Report of the Irrigation Commission, 1972)

9.57. The Table also reveals that the ground water potential yet to be utilised is fairly large in almost all the States. The analysis of towns electrified show that by 1971, 2688 out of 2699 towns had been electrified. The villages electrified are given in the Table 9.20.

TABLE 9.20

Villages Electrified in India

Population range (1961 census)	Total	Number electrified as on				
		31.3.51	31.3.61	31.3.68	31.3.69	31.3.70
Upto 499	3,51,653	522	3,986	10,265	19,934	26,222
500 to 999	1,19,086	611	4,306	9,787	17,226	21,775
1000 to 1999	65,377	843	5,918	11,567	18,128	22,501
2000 to 4999	26,565	825	5,458	9,441	12,913	15,948
5000 to 9999	3,421	197	1,319	1,963	2,397	2,638
10000 and above	776	134	560	647	682	693
Total ..	5,66,878	3,132	21,547	43,670	71,280	89,780

NOTES :

1. The data for electrified villages of Punjab and partly of U.P. is based on 1951 census.

2. The data of electrified villages for Tamil Nadu upto 31-3-61 only is based on 1951 Census and therefore population-wise break-up for all periods upto 31-3-61·

3. The populationwise break-up of electrified villages and other figures have been estimated wherever actual figures are not available.

Among the villages the rate of progress of electrification in respect of the more populous villages is higher than the rate of progress among the smaller villages. The reasons for such a development are fairly obvious—

(i) the implementation of a faster rate of rural electrification requires huge capital investment which is not readily available.

(ii) the smaller villages are flung apart and long transmission lines have to be provided for small loads thereby making the continuance of power supply to meet such loads relatively un-remunerative in the financial terms i.e., the revenue often do s not cover the interest and depreciation of distribution lines and transformers apart from the cost of generation;

(iii) the power required is sometimes seasonal and only for a few hours which tells upon the overall load factor of the generating stations; and

(iv) the large expenditure on operation and maintenance.

As long as the priorities for electrification of villages are determined with reference to financial returns, the pace of electrification of the smaller villages will be slow. Certain studies* show that the social benefits of rural electrification are much larger than strictly the financial benefits to the Electricity Board. *Procedures should, therefore, be found for a proper evaluation of the relative social benefit cost of electrifying different areas with reference to the ground water potential, the possibility of increasing production in that area, the other non-agricultural production that might be triggered off in the area etc. The correct approach to rural electrification should be through the formulation of an integrated rural development programme for cluster of villages in which the supply of electricity would be one of the inputs that could be arranged by the Government.*

9.58. If the selection of villages is done on a more rational basis, the problem of bridging the gap between social and private costs will still remain. The Electricity Boards are greatly concerned with supply of electricity at relatively high cost to rural areas as compared to industrial loads and the relatively low returns which they get. The main problem in supplying rural loads is that the consumption in kWh per kW of connected load is very low. It is also distributing that this energy consumption per unit of connected load has been fast deteriorating in the last few years as seen from Table 9.21.

TABLE 9.21

Energy Consumption in Agricultural Sector

(Pump Sets)

Year	No. of sets in operation	Total connected load (MW)	Energy consumption (m.kWh)	Consumption per pumpset (kWh)	Consumption in kWh per kW of connected load
1966-67 ..	649182	2501	2107	3245	842
1967-68 ..	847357	3175	2585	3050	814
1968-69 ..	1088774	4155	3466	3189	834
1969-70 ..	1342006	5106	3770	2809	738
1970-71 ..	1642006	6254	4110	2503	657

This difficulty could be solved by reducing the costs or by increasing the tariff for agricultural loads or by doing both. The Energy Survey Committee and the Power Economy Committee had suggested several measures for reducing the costs like standardization of designs and equipment, construction practices etc. The Naional Development Council in 1965 had recommended that schemes to meet power demand for a group of villages having clusters of pump sets should be drafted with a view to reducing the investment costs in rural areas. This Committee also feels that there is scope for designing the rural agricultural load supply system in such a way as to enable the utilisation of a given connected load for larger number of hours. *The Committee would also recommend a proper pricing of the power supplied to the agricultural loads so as to encourage the consumers to use the optimal size of pumpsets and for drawing supplies during the system off-peak hours.*

Fuel requirements

9.59. As has been described earlier the thermal power stations would be playing an increasingly predominent role in power generation in the country in view of limited hydel potential available and due to large variations in the seasonal flow of water in the rivers. On the basis of the projected requirements of installed capacity the contribution of coal based thermal stations only would be around 19.55 million kW in 1978-79, 31.10 million kW by 1983-84 and 50.59 million kW by 1990-91. Consistent with this respective generation requirements from thermal stations

*Study conduct by the NCAER and some of studies by rural Electrification Corporation.

would be 69,121 and 231.5 billion kWh. But, this would depend upon the efficient use of generating capacity and the thermal efficiency at which the power stations operate.

In order to cut down the cost of fuel and also to conserve the natural resources of coal, as far as possible, it is very important to ensure that the thermal power stations operate at an efficiency level as high as possible. It has been observed that the number of thermal power stations operating at lower thermal efficiencies has progressively reduced while the number of those operating at slightly higher efficiencies has gone up. This shift could mostly be attributed to the advancement in technology and the installation of plants with modern design and higher capacity having better efficiency level in the recent past.

At present the manufacturing capacity in this country of a thermal unit is limited to 200/250 MW which is further expected to rise in the coming years. In other advanced countries units of 500 MW or even 1000 MW size are in operation. Keeping this in view, in our study we have assumed that most of the new power stations proposed to be set up till the Sixth Plan end i.e., upto 1983-84 would have units of size 200/250 MW and thereafter upto 1990-91 the new units installed would be of 500 MW each.

To generate electricity from coal based thermal power stations, availability of fuel becomes one of the most important factors. The estimates of coal requirements by thermal stations could be worked out by segregating the use of plant depending upon its size as consumption rates greatly vary among different power stations according to both the type of boilers, pressure and temperature maintained and of course the quality of coal used. However, due to lack of availability of necessary data it has been assumed in our study that the thermal power station in operation at present would continue to consume the same quantity of coal upto 1990-91 as much they are consuming to-day. The new capacity to be added would consist of bigger units with better thermal efficiencies and the coal consumption rate would consequently go down. Keeping this in view and based on the Case-II estimates projected in Chapter III of this Report the coal requirements (including middlings for the years 1978-79, 1983-84 and 1990-91 have been worked out as 53, 80 and 144 million tonnes respectively, as set out in Table 9.22. (For details refer Appendix Table III-1 of Chapter III of this Report). Since the bulk of the coal consumed in thermal power stations is of inferior quality having low calorific value and high ash content, necessary margins have been provided to the actual requirements on this account. Further, in order to ensure that the coal requirements are fully met in 1978-79, the coal demand calculations are based on contribution of thermal power stations to energy generation as 79 billion kWh instead of the actual contribution of 69 billion kWh.

Captive power generation

In all the above calculations, it has been assumed that the total power requirements would be met through the public utility system only. In view of the prevailing shortages of power and at times due to interruptions in the continuity of power supply, there is a tendency to have captive power plants. These captive power plants being of smaller capacity would entail higher costs of installation besides working on low efficiency rate as the kWh per kW utilization per annum would be low in a large number of industries. *This Committee feels that in the overall national interest and in order to achieve the power target through the limited resources available, setting up of such captive plants should not be encouraged except in cases where process steam requirements have to be met and in the process saving incidental power generation is possible. Efforts should be made to increase the capacity of the power utility system to meet all the demands with high reliability.*

Nuclear power programme

9.60. In the first stage of India's nuclear power programme, power stations based on thermal reactors have been planned. These reactors can either be light water reactors (like Tarapur Atomic Power Station) or heavy water reactor (as has been put up at Rana Pratap Sagar). The light water reactor uses enriched uranium as fuel whereas heavy water reactor uses natural uranium as fuel. Both these reactors produce plutonium as a by-product. The second stage of our nuclear power programme is based on Fast Breeder Reactor (FBR) which would enable us to fully utilize the uranium resources as well as exploit our vast thorium reserves. A FBR uses either plutonium or U-233 (both are fissile materials) as fuel. In addition either depleted uranium or thorium is put into it. A FBR produce, in addition to power, more plutonium (if depleted uranium has been used) or U-233 (if thorium is used) than what has been consumed. It is necessary for us to have sufficiently large capacity of thermal reactors which would produce large quantities of plutonium before we could go in for the breeder reactors. The breeder reactor system is a self-sustaining system as it produces more fuel than is consumed.

Current Status of nuclear programme

9.61. At the movement total nuclear installed capacity in operation in the country is 600 MW. This includes 400 MW Tarapur Atomic Power Station and 200 MW Unit I of the Rajasthan Atomic Power Station. In addition, 200 MW Unit II of Rajasthan Atomic Power Station and 2×200 MW Madras Atomic Power Station are under construction. Work has also started on the fourth Atomic Power Station (2×200 MW) at Narora. The following table gives the expected dates of completion of the various projects on which work has commenced.

Power Station		Capacity	Expected date of completion
arapur atomic Power Station	....	2×200 MW	Operating
2. Rajasthan Atomic Power Station Unit I	..	200 MW	Operating
3. Rajasthan Atomic Power Station Unit II	..	200 MW	During Plan
4. Madras Atomic Power Station Unit I ..	..	220 MW	During Plan
5. Madras Atomic Power Station Unit II	..	220 MW	End of 1979
6. Narora Atomic Power Station Unit I ..	..	220 MW	1982
7. Naroara Atomic Power Station Unit II	..	220 MW	1983

Long-term perspective

9.62. The Department of Atomic Energy has formulated the long-term strategy for development of nuclear energy taking into account the conditions prevailing in the country. This can be summarised as follows:

(a) Installation of 1680 MW capacity (upto Narora II) by early 1983.

(b) To start work on one more 2×220 MW power station by early 1977 and completion of its first and second units in 1983 and 1984 respectively.

(c) To take up construction of 500 MW Heavy water reactor unit in 1979 and to have 9 Heavy water power reactors of 500 MW each in operation by 1990-91.

(d) To start construction of first commercial Fast Breeder Power Reactor of 500 MW by 1978 such that it can be in operation by 1986.

(e) To add 3 more 500 MW Fast Breeder Reactors to the system by 1990-91.

In short, this strategy would yield the following nuclear capacities:

	Installed Nuclear Capacity
By 1978-79	1,020 MW
By 1983-84	1,900 MW
By 1990-91	8,620 MW

9.63. *Apart from the necessity of getting the projects sanctioned and executed in time, the realisation of the nuclear power programme depends on* the adequate and timely mobilisation of resources and effort in specific related areas. One of the important requirements is that the *uranium production* should be significantly increased. At present uranium production is being done only at the Jaduguda mines. Production from this mine will be able to meet the requirements of the envisaged nuclear power programme only upto the year 1984. Hence, in order to achieve the target of 8,620 MW from the thermal reactor power stations by the year 1990-91, *uranium mining from other uranium deposits will have to be taken up. At the same time exploration work to locate additional uranium deposits would also be essential to meet the long term requirements of the nuclear power programme.*

9.64. *The realisation of the projected nuclear power programme will also depend upon the indigenous industrial back up that could be built up during the next few years.* Timely availability of special types of steel, alloy steel castings and forgings and other materials such as Argon gas for welding would be essential. *The Indian manufacturers will also have to develop their capabilities to produce many of the sophisticated and heavy components as well as special pumps and instruments required for the nuclear power programme.*

9.65. Adherence to time schedule by equipment manufacturers and delivery of the components in time is an essential requirement in order to achieve the projected targets of installed nuclear capacity. Many of the components for the nuclear power stations are heavy and over dimensioned. Transportation of such pieces of equipment will require considerable improvements to some of the national highways. Improvement of road transportation would be even more important for the transportation of equipments for 500 MW units. Integration of the electricity grids would also be important before 500 MW units could be added to the network.

9.66. While formulating the long term strategy for the development of nuclear power, the various implications of the different possible strategies have been considered. The heavy water moderated CANDU type reactor has been selected for the first stage of the nuclear power programme in India. The plutonium produced in these thermal reactors will be used to install fast breeder reactors which will utilise the vast thorium resources in India in addition to the uranium that would be discharged from the thermal reactors.

9.67. As the presently known uranium resources available in India are not very large, the total installed nuclear capacity from uranium burner reactors cannot be more than about 10,000 MW. Consequently, it has been found that developing more than one type of thermal reactor is unattractive. From the considerations of the maximum utilization of the available uranium, the potential for the highest level of indigenisation, the capability for the maximum production of plutonium and thereby support a reasonably rapid growth of installed capacity from fast reactors by and beyond the last decade of this century, and from the consideration of the economics of power generation, the CANDU type reactor has been

found to be the best suited among all the uranium burner reactors, under the conditions prevailing in India.

9.68. Considering the uranium availability and the industrial capability, the Committee has felt that it will be prudent to aim at adding about 4720 MW from CANDU reactors by 1990-91 in addition to the nuclear power stations that are under operation or construction now. In addition to this, the CANDU power programme will generate adequate plutonium to install about 2,000 MW from fast breeder reactors by 1990-91, thereby making the total installed nuclear capacity by 1990-91 to be about 8,620 MW.

9.69. In the absence of reliable data to determine the optimal level of nuclear power generation capacity that is to be established between 1983-84 and 1990-91, the Committee has felt that it would be prudent to assume a constructive estimate of 4000 MW. This is essentially a risk minimisation approach, as this assumption would lead to greater preparedness in the coal production and thermal generation. *The Committee would recommend that if possible, the nuclear capacity should be increased in the years beyond 1983-84. This should be based on a reappraisal of the nuclear power programme on the lines suggested above.*

CHAPTER X

POLICY FOR ENERGY SUPPLY TO DOMESTIC SECTOR

Fuel consumed

10.1. The greater part of the Indian population lives in villages and functions, to some extent, outside the monetised economy. The energy consumption of this section of the population is essentially for household lighting and cooking; the fuels consumed by them are mostly the non-commercial fuels viz., firewood, cowdung and vegetable waste. The richer sections of the rural population, however, consume kerosene, soft coke or even electricity, besides non-commercial fuels. The urban population mostly use kerosene or soft coke for cooking and kerosene and electricity and small quantities of kerosene for lighting. The domestic sector as a whole consumes all forms of fuel namely, vegetable waste, cowdung, firewood, soft coke, coal, kerosene, L.P.G. and electricity.

Data

10.2. There have been very few systematic studies of the pattern and trend of consumption of fuels in the domestic sector. The Energy Survey Committee of India relied on the sample surveys conducted in 1958 by the National Council of Applied Economic Research (N.C.A.E.R.) covering the cities of Bombay, Calcutta and Delhi and a sample survey of rural households all over India in 1962. The National Sample Survey, Eighteenth Round, conducted between February 1963 and January 1964 covering over 4000 urban and over 21,000 rural households also estimated the consumption of fuels in households in quantitative as well as financial terms.

The studies revealed the pre-ponderance of non-commercial energy sources in domestic energy consumption. The NCAER studies estimated that about 90 per cent of the total domestic consumption of energy in rural areas and about 75 per cent in the urban areas was in the form on non-commercial fuels. The corresponding figures of the National Sample Survey (Eighteenth Round) were 87 per cent and 61 per cent respectively. After 1964, there have been no representative field studies of energy consumption in the domestic sector. But it will be reasonable to assume that the share of non-commercial energy used in the household sector is gradually getting reduced.

Per capita consumption in the domestic sector

10.3. The different surveys have yielded divergent results regarding the use per household of non-commercial fuels in the domestic sector. Such divergence is to be expected in view of the seasonal and regional variations in the quantity of fuel consumed as well as the inability in many cases of the sample population to quantify the fuel consumption accurately. On the basis of the earlier NCAER reports, the Energy Survey Committee computed the following per capita consumption of energy in the domestic sector:—

TABLE 10.1

Per Capita Consumption of Fuel

(In coal replacement tonnes)

	1153-54	1959-60	1961.62	1962-63
Big Cities	0·38	0·40	0·40	0·41
Other Towns ..	0·37	0·38	0·39	0·39
Rural Areas ..	0·36	0·37	0·37	0·38

10.4. The Energy Survey Committee assumed a slowly increasing rate of consumption over time to take into account the income elasticity of demand for fuel consumption in the domestic sector. The Energy Survey Committee estimates show a lower trend of energy consumption in rural areas relative to urban areas. The National Sample Survey (Eighteenth Round) gave a somewhat different result. According to it the per capita consumption in rural areas was higher than in urban areas (0.34 tonnes as against 0.29 tonnes per annum in coal replacement terms). This result may be explained by the widely varying pattern of fuel consumption in the urban and rural sectors and the inaccuracies in the coal replacement measurements of the non-commercial fuels used in rual areas. It can also be argued that the rural population who gather fuels free of cost may be using them in wasteful ways as compared to the urban population who have to pay for their fuels. The latest systematic survey of energy consumption in Bombay by the NCAER has estimated per capita fuel consumption in the domestic sector as 0.44 tonne per annum in coal replacement terms.

In view of the fact that Bombay has a high per capita income and its urban character, it is to be expected that the per capita fuel consumption in Bombay would be somewhat higher than rest of the country; it is, however, noteworthy that quantitatively, per capita consumption in Bombay in 1972 is only 10 per cent higher than the per capita consumption assumed for other urban areas in the Energy Survey Committee Report for 1962-63. The Committee considered the possibility of estimating the income elasticity of domestic fuel consumption. It is felt that in view of lack of reliable data such an exercise would not give any meaningful results. The available data* regarding the trends of urbanisation in future are in terms of all the urban areas taken together and there are no estimates for the growth

of population in the metropolitan centres of Calcutta, Bombay and Delhi. It would therefore be difficult to project the demand for metropolitan cities separately. The Committee felt that the nature of the basic issues of meeting the fuel demand in the domestic sector would not change by the refinements that could be introduced in the estimation of the total requirements of fuel for the domestic sector. The Committee, therefore, assumed an average of 0.40 tonne per head of fuel consumption in urban areas and 0.38 tonnes in rural areas in coal replacement terms and that this per capita levels of consumption would continue unchanged till 1991.

Fuel consumption trends in the past in the domestic sector

10.5. As indicated in Chapter II, the consumption of fuels in the domestic sector has been calculated on the basis of the size of the rural and urban population in each year and the per capita norm of consumption. Deducting from the annual total consumption of fuel, the commercial fuel consumption in the domestic sector (for which fairly reliable data are available), the levels of usage of non-commercial fuels as so far observed have been derived. The ratio of firewood, cowdung, and vegetable waste was estimated in the Energy Survey Committee Report to be 65 per cent, 15 per cent and 20 per cent respectively of the total non-commercial fuel consumption in 1962-63. These relative shares have been adopted in this Report for the period upto 1970-71. Based on this, the trends of energy consumption in the domestic sector both commercial and non-commercial in the decade of the Sixties, are as set out in Tables 10.2 and 10.3.

TABLE 10.2

Consumption of Commercial Energy in Domestic Sector

(In Meter)

Year		Coal	Oil Products	Electricity	Total
1960-61	..	2·80	16·52	1·50	20·82
1961-62	..	2·80	18·43	1·70	22·93
1962-63	..	3·20	20·25	1·92	25·37
1963-64	..	3·50	20·25	2·06	25·81
1964-65	..	3·40	21·66	2·25	27·31
1965-66	..	4·10	20·00	2·36	26·46
1966-67	..	4·50	20·58	2·63	27·71
1967-68	..	4·30	21·39	2·93	28·62
1968-69	..	4·30	23·76	3·18	31·24
1969-70	..	4·80	25·55	3·49	33·84
1970-71	..	4·07	27·58	3·83	35·48

TABLE 10.3

Consumption of non-Commercial Energy in the Domestic Sector

(In meter)

Year		Total Non-commercial Energy	Firewood	Cowdung	Vegetable waste
1960-61	..	147·67	95·99	22·15	29·53
1961-62	..	149·64	97·27	22·44	29·93
1962-63	..	151·38	98·40	22·70	30.28
1963-64	..	156·22	101·54	23·43	31·25
1964-65	..	158·12	102·78	23·72	31·62
1965-66	..	163·43	106·23	24·51	32·69
1966-67	..	166·92	108·50	25·04	33·38
1967-68	..	170·87	111·07	25·63	34·17
1968-69	..	173·24	112·61	25·99	34·64
1969-70	..	175·76	114·24	26·37	35·15
1970-71	..	179·41	116·62	26·91	35·88

10.6. There is a steady increase in the total quantity of energy consumed in the domestic sector. However, the consumption of commercial energy has increased at a more rapid rate than the consumption of non-commercial energy. This has resulted in the percentage of commercial energy in the total energy consumption changing in the domestic sector significantly as indicated in Table 10.4.

TABLE 10.4

Percentage share of Commercial and non-Commercial Energy consumed in the domestic sector

Fuel	1953-54	1960-61	1965-66	1970-71
Commercial ..	7·4	12·4	13·9	16·5
Non-commercial ..	92·6	87·6	86·1	83·5
Total	100·0	100·0	100·0	100·0

This change in the relative proportions of commercial and non-commercial energy consumed in all the sectors of the economy are set out in Table 10.5.

TABLE 10.5

Percentage share of commercial and non-commercial energy consumed in all sectors

Fuel	1953-54	1960-61	1965-66	1970-71
Commercial ..	31·1	40·6	47·4	52·4
Non-commercial ..	68·9	59·4	52·6	47·6
Total	100·0	100·0	100·0	100·0

Forecast of demand

10.7. While, the total consumption per head of fuels in the domestic sector is likely to change only marginally over time, the composition of fuels used in the domestic sector will undergo a significant change in the coming years. The rapid electrification of rural areas contemplated in the Fifth Plan which is likely to be continued in the later Plan periods will increase the availability of electricity for lighting in the rural areas. The coal production plan also contemplates a big increase in the use of coal in the form of soft coke or low temperature carbonised coal for cooking in the domestic sector. The increase in the standard of living wil lead to increases in the use of households will use kerosene for cooking. The Committee has, therefore, projected the demand for commercial fuels in the future years on the basis of certain normative considerations. It was assumed that by 1990-91, 100 per cent of the households in urban areas and about 70 per cent in rural areas would be using electricity and about 20 per cent of the population kerosene for lighting purposes; and that 60 per cent of the urban households and 10 per cent of the rural household will else kerosene for cooking. The rest of the demand was assumed to be met by non-commercial fuels. Assuming this for the terminal year of this study, the rate of growth in the use of commercial energy in the intermediate years 1978-79 and 1983-84 were calculated. The ratio of firewood, cowdung and vegetable waste were assumed to be the same as in the past; beyond 1983-84 even though the total non-commercial energy used gets reduced, vegetable waste consumed was assumed to remain at the same level as in 1983-84 as even in subsequent years the available waste will have to be disposed off. The rest of the non-commercial fuel demand was distributed between firewood and cowdung cake as in 1983-84. On these assumptions the estimates of demand for different fuels in the domestic sector in 1978-79, 1983-84 and 1990-91 are shown in Tables 10.6 (in original units) and 10.7 (in coal replacement units).

TABLE 10.6

Estimates of fuel demand in the domestic sector in 1978-79, 1983-84, 1990-91

(in original units)

Energy Source	Units	1978-79	1983-84	1990-91
1. Soft coke	mt	6	14	20
2. Kerosene	mt	3·5	4·5	6
3. L.P.G. ..	mt	0·4	0·8	2
4. Electricity	b-kWh	8	13	25
5. Firewood & Charcoal ..	mt	132	131	122
6. Dung cake	mt	65	65	53
7. Vegetable waste ..	mt	46	46	46

TABLE 10.7

Estimates of fuel demand in the domestic sector in 1978-79, 1983-84 *and* 1990-91

(in meter)

Energy Source	1978-79	1983-84	1990-91
Soft coke	9·00	21·00	30·00
Kerosene	29·05	37·35	49·80
L.P.G.	3·32	6·64	16·60
Electricity	8·00	13·00	25·00
Firewood/Charcoal ..	125·40	124·45	115·90
Dung cake	26·00	26·00	21·20
Vegetable waste ..	43·70	43·70	43·70
Total ..	244·47	272·14	302·20

10.8. On the basis of the projections thus derived, the percentage shares of commercial energy and non-commercial energy in the domestic sector in the coming years will shift in favour of commercial energy as indicated in Table 10.8. By 1990-91, the share of commercial energy in total energy used in the domestic sector will increase to 40 per cent from less than 20 per cent in 1970-71.

TABLE 10.8

Percentage share of Commercial Energy and Non-Commercial Energy in the Domestic Sector

Fuel	1970-71	1978-79	1983-84	1990-91
Commercial energy ..	16·5	20·1	26·1	39·9
Non-commercial energy	83·5	79·9	73·9	60·1
Total ..	100·0	100·0	100·0	100·0

It may be noted that these forecasts are based on the assumption that the trend in the use of different commercial fuels will continue to be the same as in the past. If the Government take action as indicated earlier for the reduction in the use of kerosene in the domestic sector, there is likely to be a change in the percentage share of different fuels in the energy used in the domestic sector.

Availability of fuels for the domestic sector and policy implications

10.9. In Chapter V, we have summarised the likely availability of different fuel forms upto 1990-91. The limitations on the level to which coal production could be increased by 1990-91 and on the transport of coal/soft coke from Bengal-Bihar coal fields to other parts of the country, make it unlikely that the availability of coal/soft coke can be increased very much. So, for the next 15 years, as indicated here, the requirements of firewood will have to be met. It

would appear that upto 1978-79 when the demand for firewood will increase to 132 million tonnes, there will be severe shortage unless action is taken to augment the availability of firewood. The availability of LPG and kerosene may be limited by our ability to buy from the international market the required quantities of crude or kerosene. It is, however, necessary to examine in detail the availability of each fuel required in the domestic sector.

Firewood

10.10. The demand for firewood has been increasing slowly at the rate of about 2 to 3 mt/year. As long as large sections of the rural community live in conditions of poverty, there would be a tendency to use fuels which could be obtained free of cost and consequently forests will be denuded. From the level of 117 million tonnes consumed in 1970-71, the demand is likely to increase to 132 million tonnes by 1978-79. This level appears to be the highest demand for firewood that would be registered in the country and is likely to continue upto 1983-84, beyond which the demand should start declining slowly to around 122 million tonnes by 1990-91. Hence, in the next five years, we must provide for an additional demand of around 10 million tonnes of firewood and to sustain that level of production for another five years upto 1983-84. As indicated in Chapter V, the total availability from recorded fellings in the forests maintained in the public sector might go upto 35 million tonnes. The unrecorded removal of wood from tree land, private forests and trees on road sides and private land is likely to be around the present level which is about 90 million tonnes. Even this level of fellings is against the national interest. Consultations with the authorities incharge of forests conservation have clearly brought out the fact that at the current rate of fellings, forest resources are dwindling steadily as the destruction of forests is proceeding at a faster rate than their regeneration. It is relevant to note here that in addition to the demand for domestic fuels in the form of firewood whenever there is a shortage of coal, small-scale industries, especially the brick-kiln industries, tend to use firewood. It is difficult to quantify the extent of such usage. But it should be noted that any supply deficits of coal for the industries sector will increase the pressure of demand for firewood and reduce the availability of forest fuels to domestic users. *A fairly generous estimate of the forest fuel resources puts the availability of forest fuels in* 1978-79 *to be around* 94 *million tonnes* as against our estimate of demand of* 132 *million tonnes (equivalent of* 125 *mtcr). The solution to this problem lies in taking up programmes of afforestation especially with wood species which are quick growing and are capable of yielding wood for fuel purposes.*

10.11. In the past, village panchayats and villagers used to devote special attention to the maintenance of panchayats forests; but in the past few decades, this work has been neglected and as a result, the village forests have been denuded and fuel shortage is felt even in rural areas in several States. The National Commission be a scheme for introducing "social forestry"— on Agriculture gave serious consideration to the problem of supplying the fuel and fodder needs of villages and has suggested* that there should i.e., multi-purpose small forests near village sites which would supply the needs of the rural community for fuels, small timber, fodder, protection of agricultural fields and recreational needs. It identified certain quick growing species like Casurina, Cagery, Babul, Pongamia etc., which can be cultivated in small holdings and recommended a pilot scheme for the development of farm forestry in 100 selected districts of the country during the Fifth Five Year Plan. The costs of cultivation are estimated to be about Rs. 1,000 per hectare. Even if very quick yielding trees like Eucalyptus are planted in the social forests, the yield is likely to be about six tonnes per hectare per year on a ten-year cycle. As Eucalyptus cannot be planted under all climatic conditions, the yield from social forest is likely to be considerably lower than six tonnes per hectare. If we have to supply a village with 500 families, we may require as much as, say, 200 to 250 hectares of land under social forests. Such large tracts may not be available except in some areas of the country. *The social forests can, therefore, be only a supplement to the other measures for supplying the fuel needs of the rural population.* It is also necessary to exploit all available land which does not come under forest *but may be capable of supporting tree growth* like tank beds, river and channel bunds to augment the supply of fuels. *This Committee, therefore, recommends that consideration be given for the programme of tree plantations on the road sides, canal sides and railway sides (consistent with safety requirements).*

Cowdung

10.12. On the basis of our estimates of demand in future, there seems to be no problem in the availability of cowdung. Based on Indian Livestock Census estimates, the total outturn of wet dung even now is estimated to be 170 million tonnes of dry dung. The demand for cowdung for fuel is about one-third of the availabe dry dung in the country. But the major issue here is that cowdung has a better social value when used as a fertilizer instead of as a fuel. It should, however, be emphasised that, as long as large sections of the rural community remain poor and without the possibility of gainful occupation throughout the year, the use of cowdung as a fuel will continue to be practised. A certain

*FOREST RESOURCES OF INDIA—Their development and Utilisation by IM Quereshi, Director, Forestry, Forestry Research Institute and College, Dehra Dun.

**Report on Social Forestry, National Commission on Agriculture, August, 1973.

amount of dung cake will always be used in the domestic sector for lighting fires in the hearths and for the proper regulation of the flame obtained by burning of wood.

Gobar Gas plants provide the means of using both the heat value in cowdung as well as the nutrient value. Gobar Gas plants have popularised by the Khadi & Village Industries Commission as a means of improving the village economy by using local resources. They consist essentially of making a slurry of cowdung and collecting the gases produced through fermentation. The gas consists mostly of methane leaving behind organic material with high nutrient value. The Commission has been extending financial assistance in the form of loans and grants as well as technical advice in the construction of these plants. About 7,000 such plants have so far been constructed. A techno-economic appraisal* of the plants was made some years back of Gobar Gas plant. It shows that, on strict economic analysis, gobar gas would be justified for use in all States in India, except Assam, J&K, Madhya Pradesh and Orissa, which have comparatively better forest resources. A Group under the National Committee on Science and Technology examined the various possibilities for improving the design of the Gobar Gas plant, reducing its construction cost and improving the performance of the plant, especially during the winter months when the gas production goes down. The Committee has made useful suggestions which, if implemented, will reduce the cost of the Gobar Gas plants. The economic case for the use of Gobar Gas plants has been strengthened further by the recent large increase in the international price of synthetic nitrogenous fertilizers. Considering the current and the possible prices of nitrogenous fertilizers and fuels for use in the domestic sector, it is reasonable to anticipate that Gobar Gas plants are likely to become more popular. The Committee appreciates the enormous administrative difficulties likely to be encountered in popularizing the scheme and has, therefore, not taken note of any additional contribution to domestic supply of fuels from Gobar Gas plants. It is relevant to note that one Gobar Gas plant (household size) will produce fuel equivalent to only about 1.0 to 1.2 tonnes of soft coke. Even if a very large number of Gobar Gas plants were bulit in the next two decades, the energy contribution to the domestic sector will be a very small percentage of the total requirements*. But the *Committee would strongly recommend that all efforts should be made to intensify the popularization of the scheme at least in selected areas where the pattern of ownership of cattle will help in its easy implementation in view of the social benefits of the nutrient production, pollution abatement ec. possible from these plants.*

Other waste of animal and human origin

10.13. Besides cowdung, there are other waste materials like human excreta which can also provide the basis for production of gas for use in the domestic sector for heating purposes. There is a full scale night soil digester in Ernakulam capable of meeting the fuel requirements of 20,000 people. At the village level, there is one in Maharashtra State. But these units are not economically viable and there are various taboos attached to the use of these materials. The Committee, therefore, does not foresee any significant contribution to the fuel supply from these sources.

Vegetable waste

10.14. Waste material of plant origin has contributed a significant share to the fuel needs of the rural community. Bagasse which is now used as a fuel is capable of being used as the raw material for the manufacture of paper and gives a better social return as an industrial raw material than as a fuel. Similarly, straw and stovers of crops are used as roughages for cattle feeds and should, therefore, be used as such instead of as fuel. But all other waste material has to be disposed of only as fuel. The Committee has, therefore, assumed that even when the need for non-commercial fuels in the economy goes down, the level of usage of vegetable waste upto 1990-91 will continue to be the same as in 1983-84.

Soft coke

10.15. The level of use of soft coke is limited, on the one hand, by the emphasis on convenience laid by domestic consumers in the urban areas and the affluent sections of the rural community and, on the other hand, by private cost involved in the purchase of soft coke as against vegetable waste or cowdung which is obtained practically free of cost by the poorer sections of the rural community. Any effort at popularizing soft coke use will have to depend heavily on the feasibility of reducing the price of soft coke at the consumer end. In States like West Bengal, Bihar and Uttar Pradesh, which are not very far from the area of production of soft coke, it may be possible to induce people to use soft coke made in *bhattas* without any subsidy provided adequate supply of soft coke is assured. But in the last five years, soft coke consumption has shown a declining trend from the peak level of 3.2 million tonnes in 1969-70. This is on account of the low priority given for movement of soft coke in the railway system and the increasing difficulties experienced in moving soft coke by rail. The *bhatta* method of production of soft coke calls for the use of coking coal, at least of the lowest grades available. But methods are available for the conversion of even non-coking coal to somkeless domestic heating fuel by using low temperature carbonization process. Two variations of

**Note* : If two million gobar gas Plants were constructed by 1990-91, their output will be less than 2 per cent of domestic fuel requirements.

this process have been developed in the CFRI at Dhanbad and RRL at Hyderabad. A plant designed to carbonize about 900 tonnes of coal which will produce about 550 tonnes of coke per day and serve the needs of over 8 lakhs of population, or 1.6 lakhs households, would require an investment of nearly Rs. 10 crores. The investment in coke production to meet the requirements of one household will work to nearly Rs. 1,200; the coke produced will cost Rs. 250 per tonne at the point of production. If the coke could be sold at the price, the plant is commercially viable. The economics of the plant improves with the extent of by-product recovery; but by-products can be recovered economically only when the plant is large, say, about three times the size discussed. Such aprocess can be used near coalfields and the coke distributed from central production points and, even at the high level of prices of other fuels prevailing now, the products of this unit can be sold only in highly urbanized centres*.

CFRI has also developed smaller plants like moving bed carbonisers which can be based to supply the requirements of smaller towns. But these processes require coking coal although of an inferior grade. The Committee woud like to emphasise the importance of developing cheap solid domestic fuels which can be used in small towns as well as in rural areas by sections of the population who use firewood now. *The Committee would therefore urge that the possibilities of setting up plants for the manufacture of solid domestic fuel to suit the requirements of different sizes of urban centres should be studied further, with reference to coal available in the nearby Coalfield. The possibility of reducing the cost of soft coke to the consumer by subsidizing the transport and trading margins on soft coke or by raising the required funds by way of surcharge on the price of kerosene, should be examined.* This additional taxation on kerosene and the subsidy on soft coke will have the effect of balancing social benefits and private benefits that arise in the use of kerosene which depends on imported raw material and of soft coke which depends on indigenous raw materials. *The Committee has taken a somewhat cautious view about the level of soft coke that may be used in the economy; but it recommends that all efforts should be made to increase the level as high as possible.*

Town gas

10.16. The cost of setting up gas production unit and the distribution pipelines from the gas works to the households would call for an investment of about Rs. 2,000 to Rs. 2,500 per family inclusive of the private cost of installing the gas meter, gas oven, etc., even in densely populated cities. A cost-benefit analysis of supplying coal gas as a domestic fuel to substitute kerosene indicates that this is economical only in metropolitan areas, especially those where the population density is very high and where there is an industrial demand for gas in addition to domestic demand (Please see Chapter VII).

Kerosene

10.17. Kerosene has proved to be the most popular among the fuels used in the domestic sector in view of its convenience of use. Inspite of the price prevailing upto 1973, kerosene was cheaper than the other fuels available for use in the domestic sector. The increase in price in 1974 has made the price of kerosene somewhat higher than the price of an equivalent quantity of other commercial fuels like soft coke or charcoal. But on account of its greater convenience of usage, kerosene will continue to be a popular fuel. The demand for kerosene can be controlled only by proper distributive arrangements. In our estimates, we have assumed that the trends in the use of kerosene will continue to be the same as in the past unless controlled by the Government. Even on this assumption, the share of kerosene in the total oil products used in the economy will be only 7.5 per cent in 1978-79, 6.5 per cent in 1983-84 and 5.3 per cent in 1990-91. The replacement of kerosene by other fuels in the domestic sector would depend primarily on the availability of other fuels. It is reasonable to assume that in big cities like Bombay or Calcutta, only coal gas can replace the use of kerosene; while, in the rural areas, the sections of the population, who would have normally switched over from firewood to koresene, can be persuaded to use soft coke, provided its price is lower and its availability is better than that of kerosene.

LPG

10.18. Liquified petroleum gas is one of the light end products in the refinery and its availability ranges from 1.5 to 2.5 per cent depending on the measures used for reducing refinery losses and refinery fuel consumption. In our Report, the use of LPG has been estimated on the basis of its availability from domestic refineries. If, on account of the measures recommended in this Report, the level of oil used is reduced and the refining capacity operating in the country is also reduced, the availability of LPG will go down and to that extent, this need has to be met by substitute fuels.

Electricity

10.19. The rapid electrification of villages has been accepted as a policy by the Government with a view to upgrading the quality of life in the villages and to make it possible for rural industries and agriculture to function efficiently. In

*As mentioned earlier in Chapter VII, the Committee in its Report on the Fue Policy for the Seventies recomended the setting up of two LTC plants, one at Calcutta and one near Hyderabad. The Government have approved these two proposals recently!

the estimates of the use of electricity, it is assumed that by 1990-91, 100 per cent of the urban areas and 90 per cent of the rural areas would be electrified; but the number of households using electricity for lighting in the rural areas has been assumed to be 70 per cent, compared with 100 per cent of the households in the urban areas. On this basis, the share of electricity used in the domestic sector to the total electricity consumed in the economy will be 8.94 per cent in 1978-79, 9.55 per cent in 1983-84 and 8.22 per cent in 1990-91. However, the committee would like to emphasise the increased social benefits possible if rural electrification is undertaken with adequate organisational and procedural improvements so as to ensure that maximum number of households are electrified in each village to which electricity is extended. In the absence of such improvements, inspite of large investments in rural electrification, only a section of the population is benefited.

Efficiency Improvement

10.20. Studies by the CFRI have shown that the oven and other cooking appliances used in the domestic sector using firewood and soft coke do not have design characteristics which would optimize the use of fuels. Even small improvements in the design of the domestic chulla will increase the efficiency by 10 to 15 per cent. Similarly, the work done at the Indian Institute of Petroleum has shown that kerosene using appliances can also be improved in their designs so as to increase their efficiency. Considering the large share of energy used in the domestic sector, the social gains as well as private gains to be obtained by improving the efficiency of utilisation of fuels in the domestic sector would be enormous. *The Committee would therefore recommend that research and development should be undertaken on the optimisation of the design of the chulla and other appliances used in the domestic sector and also other administrative action taken to ensure that the appliances marketed conform to those design requirements.*

Major implications of policy

10.21. From the discussion above, it is clear that the present trend of increasing pressure on non-commercial fuels for meeting the fuel needs of the domestic sector is likely to wane from 1978-79. The level of usage of non-commercial fuels is likely to stay at a plateau for the next five years upto 1983-84. But this expectation is based on the assumption that the commercial fuels will be made available in increasing quantities as indicated in the forecast. The supply of soft coke to the levels anticipated will depend not only on the setting up of production facilities but also on the provision of transport facilities and procedures for transportation which will enable an uninterrupted supply of these fuels to hundreds of thousands of supply points. It is also noteworthy that even if the quantities of commercial fuels are available, the financial capability of the consumers to use these fuels in preference to fuels which they may obtain free of private cost, is likely to be limited unless relative prices are properly regulated and the income redistribution proceeds at a fast pace. The low income level of the rural population is likely to be a constrain on the widespread use of electricity for domestic purposes as contemplated in this Report. *The Committee would like to draw attention to the fact that the problem of substitution of non-commercial fuels by commercial fuel in the domestic sector has to be considered with due regard to the overall economic implications of the use of different fuels in this sector and the pricing and distribution policies should be based on a full understanding of the social cost of the use of different fuels.*

CHAPTER XI

COSTS AND PRICES IN ENERGY SECTOR

Cost to the Economy

Various aspects of production and utilization of different fuels in the economy have been considered with due regard to their costs of production within the country or cost of obtaining them from abroad. By their very nature, coal, oil and hydel resources occur in environments which differ widely from one another. Consequently, costs of producing fuels and converting them to useable forms vary widely.

11.2. Prices at which fuels are made available to the consumers are determined by the costs of production, transport and trade margins, scarcity values, taxes and subsidies on these fuels. The level of taxes is usually designed with reference to several objectives like increasing Government revenues, encouraging production from sources which would otherwise be abandoned or remain untapped, discouraging the use of fuels which are in scarce supply, etc. On account of the interaction of these factors, the change in the consumer prices of fuels over time will not depend solely on the changes in the cost of production of the fuels.

Past trends in energy prices

11.3. In India, as in many other countries, there has always been an urge for public intervention to ensure that prices of energy are kept at as low a level as possible. It is common experience in many countries that the rate of increase of fuel prices is lower than the rate of increase of prices of other commodities whose prices are determined by market forces without intervention by the Government. The data for the Sixties indicate that in India the change in the index of prices of fuels was less pronounced than changes in the index of prices of all commodities, food articles or of industrial raw materials. Table 11.1 bears this out:—

TABLE 11.1

Index Numbers of Wholesale Prices (1960-61 *to* 1970-71)

(Base : 1960-61 = 100)

Year		Item			
		All commodities	Food articles	Industrial raw materials	Fuels, power, light and lubricants
1960-61	..	100·0	100·0	100·0	100·0
1961-62	..	100·2	100·2	98·1	101·8
1962-63	..	104·0	105·6	95·9	105·1
1963-64	..	110·4	115·5	93·2	120·0
1964-65	..	122·5	135·6	113·7	122·5
1965-66	..	131·9	144·7	130·3	126·3
1966-67	..	150·2	171·3	155·4	136·9
1967-68	..	167·6	203·0	153·4	144·6
1968-69	..	165·7	197·1	154·3	151·3
1969-70	..	171·9	197·0	176·7	157·9
1970-71	..	181·5	201·1	193·5	164·7

11.4. A study of the relative movement of prices of different fuels during the Sixties shows that the rate of increase in the price of electricity has been lower than that of coal. Among oil products, the rate of increase in the price of diesel has been lower than that of petrol (motorgas). See Table 11.2 below:—

TABLE 11.2

Index Numbers of Wholesale Prices of Selected Fuels in India— (1960-61 *to* 1970-71)

(1961-62 = 100)

Period		All commodities	Coal	Electricity	OIL	
					Petrol	Diesel oil
1961-62	..	100·00	100·0	100·0	100·0	100·0
1962-63	..	100·24	104·9	109·0	101·9	102·1
1963-64	..	108·15	112·2	115·1	120·2	108·9
1964-65	..	122·06	116·3	119·6	120·6	109·3
1965-66	..	131·89	121·8	124·9	127·0	110·9
1966-67	..	152·84	128·5	137·3	131·5	119·3
1967-68	..	159·94	147·9	138·5	144·5	119·3
1968-69	..	165·40	168·2	143·3	148·6	121·7
1969-70	..	171·50	166·0	143·9	160·0	122·8
1970-71	..	181·10	167·9	150·2	175·5	121·1

NOTE : Index numbers of wholesale prices of other Oil products are not published.

11.5. *A proper price policy for the fuels will have to be based on an adequate appreciation of the production cost of each fuel over time. The price policy should take into account the interests of the producer, the consumer and the nation.* From the point of view of the producer, a sound system of prices should give the incentive to produce the required quantities of energy and should assure its regular production at the minimum of cost by putting pressure on the management to select optimal projects and operate them efficiently. The relative price of fuels of different qualities should be such as to enable the production of different qualities of fuels in the required quantities and prevent the wasteful production of fuels which are in scarce supply. The price policy should also enable the industry to undertake and implement a long-term policy of exploration and technical research to improve the efficiency of production and transformation of energy. From the consumer point of view, the price system should provide the energy at the lowest possible costs, encourage him to use the type of energy that best suits his particular needs and encourage the use of fuels whose supply is relatively abundant and discourage consumption of fuels which are relatively scarce. From the national point of view, the fuel prices should ensure that the pattern of use of fuels is in keeping with the optimal pattern of production determined with reference to the long-term availability of fuels and their costs.

11.6. In practice, a price system cannot work equally satisfactorily from all points of view. Many of the problems of the energy situation in India appear to be due to price policies in the fuel sector which have been concerned, possibly to an excessive extent with one individual function of the policy namely that of supplying consumers with energy at the lowest possible costs. As a result, production of sufficient quantities of fuels has suffered, and the country has also been increasingly dependent on external sources of supply. In future, in designing a rational price policy for the energy sector, appropriate attention should be paid to all the three functions referred to earlier.

11.7. While the procedures for price determination will vary with the nature of the fuel industry for whose products the price is to be fixed, *the Committee feels that the Government should indicate a reasonable rate of return to be fixed for the fuel industries as a whole which would serve as a guideline for any committee which is entrusted with the task of price fixation for any fuel.* There has been significant variation in the rate of return allowed by different committees in the past. Taking note of the objectives of a rational price policy in the *energy sector. Energy Survey Committee* (1965) *had suggested that the fuel industries should yield a return of at least* 10 *per cent on the investment. This Committee would like to endorse the view of the Energy Survey Committee. The price fixed for any fuel, coal, oil or electricity should be such that the particular fuel industry, as a whole, is enabled to earn a return of at least* 10 *per cent on the investment made in the industry.*

Price policy for the coal sector

11.8. In any coalfield, in the normal course, the more easily mineable deposits are exploited first, leaving the deposits available at greater depths and occurring under more difficult mining conditions to be exploited later. This would lead to progressively increasing cost of mining coal. However, as only a very small fraction of the total deposits available in the country has so far been exploited, inspite of the increasing level of coal production, the costs of mining have not increased significantly. Cost of coal production has been analysed by several committees which were set up to enquire into the production costs and fix a reasonable price for coal. After examining various possibilities, all the committees starting with the Coal Price Revision Committee in 1958 had decided to fix the price on a 'cost plus' basis where the "plus" factor was expected to reflect a fair margin of profit. For determining costs of products, data were collected by team of cost accountants for the Coal Price Revision Committee in respect of 63 collieries which were selected in consultation with the industry. Analysis revealed that there were wide variations in the costs of production even among collieries which were located very close to each other. Even when the elements of costs were disaggregated, these elements of costs could not be correlated with factors which are normally considered to determine the cost like the size of collieries, depth at which coal is mined etc. It was also noticed that

the cost of extraction of coal does not bear any correlation to the quality of coal. The extraction of lower grade coal in some fields is costlier than extracting good quality of coal from other fields. The committees which were to fix the price of coal with reference to the cost of production had to adopt certain subjective standards to determine what might be regarded as "normal" for each item of the cost of the production. Though the committees have not explained the basis for selecting "normal cost" of each element of production costs, the "normal cost" determined by each committee is very close to the mean of the observations of cost considered by the committee. Table 11.3 sets out "normal" elements of cost of producing a tonne of coal in India as worked out in two such reports—one in 1957 and the other in 1971.

TABLE 11.3

"Normal Costs" of Coal Production—1957 and 1971

	Cost in Rs. per tonne of coal as commuted in	
	1957	1971
1. Wages, salaries and administration	11·25	19·50
2. Stores	1·75	3·80
3. Welfare Expenditure & Misc	1·10	1·93
4. Power Royalty etc.	1·85	1·80
5. Depreciation	1·70	1·80
6. Cess, brokerage etc.	0·25	0·22
7. Total cost of production*	17·90	28·05

NOTE: *This does not include interest on working capital and "margin of profit". These elements were added to arrive at the price of coal.

In effect, a major portion of the increase in cost from 1957 is attributable to the rise in wage cost. However, a large part of the wage increase appear to be in the nature of neutralization of the increase in price of food articles. (See Table 11.1).

11.9. It is noteworthy that the element of depreciation in the cost taken as "normal" has varied marginally only over a period of 14 years. This is partly due to the fact that price fixation studies selected samples of coal mines which were weighted in favour of the old and private sector mines; the public sector was active in opening new mines in geologically less advantageous locations and the average net fixed assets committed per tonne of coal production was considerably higher in the public sector as compared to the private sector. Many of the high cost mines were opened in outlying coal fields and in many cases the production from such mines were contracted for supply to specific consumers at prices which were specially negotiated. The study by the Bureau of Industrial Costs and Prices revealed that the price per tonne of production (as per the samples examined by them) was as follows:

	Rs. tonne		
	Private sector	Public sector	Overall
For all regions: (other than Singareni)	8·39	24·73	14·31

NOTE:—The net fixed assets in Singareni Colliery were computed to be higher than Rs. 24·73 per tonne.

An examination of the new investment proposals in the coal industry indicates that additional production of coal would involve much larger investment per tonne of coal to be produced.

11.10. The discussion above, brings out the difficulty of the problem of determining the cost of production of coal which can be considered reasonable for all the producers of coal. This problem has, however, undergone a change in character by the nationalisation of all the coal mines in the country. It is, possible now, to determine the costs of production which will be acceptable to the public sector coal companies which manage all the mines in one region or coalfield by taking into account, the costs of producing the coal from all the mines under its management. To start with, computation may be done on the basis of cost accountancy studies but it is necessary for long run efficiency of resource utilization. But economically relevant costs are determined for purposes of price fixation.

11.11. The problem of fixing the consumer price of coal with reference to the quality of coal will continue even now. Coal is not a homogenous commodity as its quality varies very widely from mine to mine. The consumer specification for coal involves several characteristics like calorific value, percentage of sulphur, percentage of inerts, and fusion temperature, etc. While the costs of coal production are not related to any of these "Qualities" or "factors", the value of coal to the consumer depends on a number of these factors.

Taking all these issues into account the Committee would recommend the following principles to govern coal prices—

(1) *Coal prices should be fixed with reference to the geographical area from which coal is mined.*

(2) *Price fixed for the coals produced in each area should cover the total costs of production and should yield a net return of at least* 10 *per cent on the capital invested in producing coal in that area.*

(3) *Differential price fixed for coal of different qualities should adequately reflect the value of the specific qualities to the consumer as well as the relative scarcity of coal of different qualities.*

11.12. Operationally, the determination of coal price on these principles could be done by adopting the following procedure: Coal mines in India can be divided into certain geographical groups, each group consisting of one or more coalfields. The price of coal in each area could be determined with reference to the cost of producing coal to the required level in that area. As the Government or the Coal Company draws plans in advance for attaining specified levels of production in each of the coalfields, the production plans would be available for each coalfield from which the cost of producing coal can be determined. If all the full details of the production plan are not available at the time of price fixation, this can be done by selecting a "representative mine" in the coalfield which will set the trend of costs of production of coal in that field during the period for which the price will be in operation. This cost can be called the "bench mark" cost; the average selling price of all the coal from the area should be fixed to assure yield of net return of at least 10 per cent on the invested capital after meeting the "bench mark" costs.

11.13. "Bench Mark" price will apply to the coal of the quality which is produced in the largest quantity in the area. All coal produced in the area could be arranged in price groups with reference to the price and quality coal of bench mark. The price groupings could be made with reference to the following:—

1—Calorific value.

2—Ash content.

3—Moisture content.

4—Sulphur content.

5—Content of other impurities like grid, abrasive material etc.

6—Size of coal.

Depending on the value of the different characteristics of coal to the consumer, a premium or a rebate could be allowed on different qualities of coal with reference to the price and quality of the bench mark coal. Over and above this, for taking into account the rapidly exhaustible quality of certain types of coal, a penalty value for scarcity of coal of certain qualities could be added. Point values could be worked out for each of these factors.

11.14. In fixing the point value and in determining the price groupings, it should be ensured that the total coal sold as per the schedule of prices determined in the coalfield should give a minimum return of 10 per cent on the capital invested in coal production in the field as a whole.

11.15. As such price fixation will be done with reference to the production proposed for a period of 5 years, it will make the coal industry conscious of its responsibility in achieving production at certain costs. Its failure in this regard will lead to a loss; while improvement achieved in actual implementation of the projects will increase the profits. The period for which the price should be fixed will depend on different circumstances but if stability is envisaged in the level of wages and prices of inputs, it should be possible to fix the price for at least 2/3 years at a time. In times of abnormal inflation, it will be necessary to link the price of coal to certain indices like wage costs or costs of major inputs. Such price fixation while defining the responsibility of coal industry as indicated above, would also enable the coal consuming industries to project their cost of production on a reasonable basis.

Price policy for the oil sector

11.16. As indicated in Chapter VIII, India's production of crude from indigenous sources will be adequate to meet only part of the demand for such products. The rest has to be obtained from other countries either in the form of crude or in the form of products. When crude is obtained, it has to be refined before use and the process of refining gives rise to a set of joint products. These products fall into three main categories, namely, the light distillate products, the middle distillate products and the heavyends. Each of these main categories can be split into sub-categories and by blending with other products or by addition of additives, they are converted to petroleum products with specifications which conform to specific consumer needs.

11.17. Each refinery attempts to adjust its production to conform to the pattern of demand for products that it has to serve. In the United States where the demand for motor gasoline forms a high proportion of the total oil products' demand, the refineries tend to maximise the yield of motor gasoline in the refineries. In certain countries, where demand for fuel oil is high as compared to other products, as in Japan, the refineries maximise the yield of heavyends. In countries like India, where the major share of demand comprises diesel oil and kerosene which are middle distillates, the production pattern of the refineries is normally geared to maximise the yield of middle distillates. (See Chapter VIII). In a refinery it is possible to adjust to a great extent the production levels of the products within each main category without major investment costs. But decreasing the proportion of the heavier products and increasing the share of lighter products will call for investments in equipment which can crack the heavier products into lighter ones. The yield of even the main categories using the same equipment will depend on some extent on the quality of the crude which is processed in the refinery. Certain crudes which yield on straight distillation, a larger proportion of light ends are referred to as light crudes whereas those which yield a larger proportion of heavyends are called heavy crudes. Due to the international pattern of demand for different products there is relatively a larger demand for light crudes and in international market light crudes command higher

prices*. The changing price of oil in the international market gives rise to the problem of fixing a proper price for crude that is produced within the country. As long as international price of crude was relatively low, as in the period prior to October 1973, the crude produced in India was priced with reference to the international price. After the sudden multi-fold increase in price after October 1973, Government have fixed the price of crude at a relatively low level as compared to the price of crude in the international market and has proposed to collect a surcharge on indigenous crude which will be used to finance a Petroleum Development Fund. Even with the addition of the surcharge, the price of indigenous crude has been kept at a level significantly lower than the price of similar quality crude in the international market. *The Committee considers that the producer price of crude produced in India should at least be equal to the long-term cost of producing crude in India and the difference between such a price and the prevailng international market price at any point of time should be collected by the Government as a tax. In effect, the refineries should get Indian crude at prices equal to the international price of similar crude.* Fixing the ex-refinery price of Indian crude lower than the international, would involve subsidizing the consumption of oil products. Unless the case for it is examined with reference to the classes of people who consume oil products, it is not rational to subsidise the price of crude, especially when any subsidy that is considered desirable for a section of the oil product consumers can be made available by suitable adjustments in taxes and subsidies on that particular product.

11.18. Given the quality of crude and the mix of products that are to be obtained from the crude, the investment requirements for a refinery and its operating cost can be determined. There are international "norms" regarding the investment and operating costs for converting a standard quality of crude to a given product†. It is, therefore, possible to relate the cost of oil products to the cost of the crude and later allow a reasonable rate of return to the refinery industry and fix the producer price of each oil product. In almost all countries, taxes on oil provide large revenues to the Government as the oil products are among the goods which are heavily taxed. The consumer price of a product is made up of the producer price, taxes and the trade and transport margin. The price fixation of oil products could therefore be made on the basis of a study of the pattern of demand to which a refinery has to cater, the required investment and operational cost and the crude prices and the product price could be linked to the price of crude. But for a number of reasons set out by them, the Oil Prices Committee‡ had decided to fix the producer price of each product on par with the import price. The price of each product relevant to a crude price on a particular day was determined with reference to the international price of such products and the product prices were allowed to be changed with reference to changes in the crude price. The latter changes were determined on the basis of the formula that for every change of 10.0 U.S. cents per barrel in the crude price, there would be 4 per cent change in the product price. The international price of products in relation to crude price has been varying from time to time and in effect the import parity was not maintained over time, by the adoption of the price formula followed in India.

11.19. *In the coming years when India is likely to produce most of the products by refining of crude within the country, the Committee does not see any particular advantage in maintaining the "price parity" formula for fixing ex-refinery prices.* As in any other country, the price of products at the refinery level could be fixed with reference to the cost of producing that product after attaining a reasonable return to the refiner. However, in the case of a refinery, as products are produced jointly, there is the problem of allocation of production costs as between the different products. A number of methods have been adopted for pricing the joint products in several industries. Similar methods could be adopted for the oil industry also. The prices could be fixed in such a way that the refiners get an ex-refinery price for different products which, taken as a whole, cover the cost of inputs, the cost of refining and allow a reasonable profit on the investments made in refineries. It is possible to determine with reference to a standard crude, the costs of processing by straight distillation. The costs of further processing to increase the share of any particular product in the product mix, will be different with each product. Using these cost data, it would be possible to determine the index of production costs of different products. Such indices along with the crude price could be served as the basis of determining the ex-refinery price of the various products.

11.20. The price at the retail level will have to be fixed by imposing taxes or subsidies over the refinery price and adding the transport and trade margins. Depending on the objectives of the Government, namely, whether it should encourage or discourage the use of a particular product, and judgement of the Government of the subsidy to be given to the consuming sector, Government could vary the taxes and subsidies from time to time. Government have recently appointed a Committee to go into the pricing of oil products. *At this stage, the Committee would like only to suggest that there should be a serious examination of the need to continue the import parity formula for product pricing and to*

*Other factors like sulphur content also affect the price of crude significantly.

†Nelson,s ratings is an example of such norms.

‡ There have been 3 reports so far—(1) Talukdar Committee Report; (2) Damle Committee Report; (3) Shah Committee Report,

evaluate other possible methods of fixing prices which will best subserve the national interest.

Price policy for the power sector

11.21. Some implication of a rational price system for the power sector with reference to the quantum and intensity of their power consumption by different classes of consumers have been dealt with in Chapter IX of this Report. The committees which have examined the pricing of power in India have all recommended that the revenues collected by the Electricity Boards by sale of power should be adequate to cover all the costs and should allow a fair return on the investments made on power generation, transmission and distribution. The report of the Committee on the Working of the State Electricity Board, 1964, (Venkataraman Committee) had suggested than the tariff should be so fixed that the gross collection covers all the recurring costs and leaves a return of 11 per cent on the investment made by the Electricity Board. This Committee had examined the question with reference to the Electricity (Supply) Act and suggested that this 11 per cent should be distributed as 1½ per cent towards electricity duty, ½ per cent towards general reserve, 6 per cent towards interest charges and 3 per cent as net profit. On a comparable basis, the rate of return suggested by the Venkataraman Committee for electricity is lower than the rate of return suggested here for the coal industry. However, the rate of return is well below the minimum of 9 per cent. The actual return on investment made in the electricity industry is substantially less than even 9 per cent. The report of the Finance Commission 1973, which examined the finances of the State Electricity Board during Fourth Five Year Plan has stated: "Despite this all round awareness of the need to achieve certain minimum rates of return on investments made in power projects, the working results of State Electricity Boards, far from registering any improvement, have suffered set-back during the current Plan period. The forecasts furnished by the State Governments point to no significant improvement in the standards of performance of State Electricity Boards in financial terms in the Fifth Plan period. Taking all State Electricity Boards together, while their revenue receipts would have increased from Rs 387 crores in 1969-70 to Rs. 692 crores in 1973-74 reflecting the growth in generation and sale of power and revision of tariff, their net surplus, after setting on revenue expenditure and obligatory transfers to depreciation fund, would have declined from 4.2 per cent to 3.3 per cent on the capital basis. The rate of return will more or less be of the same order during the forecast period" *This Committee would like to emphasise that the inadequate returns from electricity industry will seriously affect the power programme and recommend strongly that the electricity tariff should immediately be revised in all the States so as to give the rates of return as suggested by the Venkataraman Committee. In fact, the Committee would like to recommend that the returns on investment in electricity should be 10 per cent in keeping with the rates of return expected from other energy producing industries. The basis of pricing suggested here should be applicable not only to State Electricity Boards but also to other power generating agencies like the Department of Atomic Energy, Central Electricity Authority, DVC. etc.*

11.22. The determination of the relative price of supplying power to various categories of consumers and for the same class of consumers during different seasons of the year and for different parts of the day calls for a close analysis. The system of pricing power uniformly throughout the year will not lead to optimal utilization of the power system capability. A given installed capacity utilized at high load factors will bring down the total cost of generation. No consumer however will require power of the same intensity throughout year, or even throughout a day. There are specific periods during which most of the consumers would prefer to draw their electricity requirements if the price of electricity is the same at all times. Supplying electricity during the peak hours, therefore, would involve a higher cost than supplying electricity during the off-peak hours. To some extent, the divergence in the cost of power generation for peak supply and off-peak supply could be reduced by designing an optimal power generating system with due regard to the structure of the load that faces the system. Even then, the difference in the cost of supplying the requirements during the peak hours of the day or during the peak season in a year would be significantly higher than the supplies to be met during other parts of the year or the day. *The Committee will, therefore, recommend that the electricity tariff should be designed so as to discriminate adequately between the use of power during the peak periods and during off-peak periods. As the difference in the peak demand and off-peak demand is very large in this country, the tariff should include a penalty for use of power during the peak hours so that atleast over a period of time the load curves of demand are flattened to a more reasonable level. This would bring about substantial savings in the investment cost in the power sector.*

11.23. There are often suggestions for subsidizing the cost of power to particular consumer categories with a view to enable them to produce more of certain products or to reduce their costs of production. In the industrial sector, such suggestions are mostly in respect of industries which are intensive users of energy like steel, aluminium, fertilizers and electro-metallurgical industries. The case for a subsidy should be carefully examined in each case to see whether such a subsidy is really called for. *The Committee is of the view that there is generally no case for subsidizing the cost of power supply to any industry.* As most of the intensive energy users will operate at a very high power factor and

load factor, the cost of supplying power to them would be relatively lower than the cost of supplying power to other industries whose consumption is less intensive. While fixing the price of power supply to such power intensive industries, the fact of the lower cost of supplying such needs should certainly be taken into account; but there appears to be no case of going beyond this and give a subsidy to any of these industries. In the agriculture sector, power rates have been kept very low during the initial period of planned development; this should be considered as a promotional tariff operated during a period when the use of power in agriculture was a very small fraction of the total power supply to all sectors of the economy and when the Government was keen on promoting a larger use of power in the agriculture sector. *At present when the demand for power from the agriculture sector is a substantial portion of the total demand and when there is no longer any need for a promotional campaign to encourage the use of power in the agricultural sector (except perhaps in certain selected pockets in the country), the tariffs introduced earlier need correction. The Committee would strongly recommend that the agricultural loads should be charged with due regard to the cost of supplying power to the agriculture sector. At the same time, all measures should be taken to bring about a better utilization of the connected loads in the agricultural sector (like roastering of agricultural loads) which would enable the reduction of the cost of power supply to the agriculturists.*

CHAPTER XII

TECHNOLOGY PLAN FOR ENERGY SECTOR

12.1. The energy sector extends to so many fuel forms, their production, transformation and utilisation that there are vast areas where research and development work can be undertaken. But in a country like ours with limited resources of men and materials for R. & D. work, efforts in research and development should be oriented towards solving specific problems which are relevant to our country. The priorities for action in R. & D. should be determined with reference to the nature of the problem, the chances of our solving the problem, the results of efforts undertaken on similar problems in this country and abroad so far and the constraints on resources available for R. & D. work.

12.2. The important problems in the energy sector identified in this Report are the following:—

—resource-wise India is very inadequately provided with oil reserves and coking coal required for metallurgical industries; but fairly adequately endowed with non-coking coal resources;

—the non-coking coal resources are poor in quality and their beneficiation and transport involve heavy cost;

—nearly half of the energy needs of the country are still obtained in the form of non-commercial fuels and the continued use of these non-commercial fuels will lead to heavy social costs, but the shift from non-commercial to commercial fuels is possible only if cheap commercial fuel substitutes could be provided to the rural poor;

—within the country the distribution of fuel resources as between the regions is somewhat uneven and energy transportation involves heavy costs.

12.3. In the light of these, the research and development efforts should be directed towards:

—increasing the efficiency of use of fuels;

—making economically efficient use of lower grade coal wherever it can be used;

—improving the technology for the use of coal/coke in areas where oil products are used at present;

—developing techniques for the economic transfer of energy over long distances;

—developing new technologies for production of cheap commercial fuels for use in the domestic sector;

—developing mining techniques for improving the efficiency and reducing cost:

—developing new sources of energy to supplement the fossil fuel supplies.

Increasing the efficiency of use of fuels in all sectors

12.4. There are indications that without any large shifts in the technology of fuel utilisation, large savings of energy can be effected by reducing the fuel required per unit of output in a number of industries by adoption of more efficient methods and procedures of use. As early as 1962, the Government of India obtained the services of two experts from the National Fuel Efficiency Service of U.K. whose findings indicate that in many factories 15 per cent saving in fuel consumption was possible and in some the saving could be as high as 50 per cent. Some of the micro-level studies undertaken by the National Productivity Council through its Fuel Efficiency Service reinforce the findings of these experts. There are numerous instances where the choice of fuel has been made without due regard to national considerations. Often a particular fuel is chosen on the advice of suppliers of equipment without serious considerations of the financial—let alone the economic implications of the choice, as the element of fuel cost is often only a small fraction of the total production cost. It is necessary therefore that the choice of fuel by each industry should be done with regard to technical and national interests. The two objectives of ensuring that the optimal choice of fuels is made and the optimum use of fuel is made efficiently in the industries should be achieved by having a National Fuel Efficiency Service. A study conducted by the National Committee on Science and Technology has indicated that such a service which essentially requires trained fuel experts would not suffer for want of necessary technically qualified personnel. *The Committee therefore recommends that a National Fuel Efficiency Service should be organised a searly as possible. The Service should also be armed with adequate authority to ensure that their considered views on selection of fuels and on the level of efficiency to be achieved in the use of fuels is accepted by the fuel consumers.*

12.5. The National Fuel Efficiency Service can be organised either as a central agency extending its activities to all regions and all sectors of the industry or by forming separate regional or industry-wise Fuel Efficiency Services. Whatever be the organization, there is need to involve in

the Fuel Efficiency Service, officials of the Central and State Governments whose responsibility extends at present to problems of fuel usage. *The Committee would like to emphasise that, besides organisational arrangement, there is need for setting up facilities for training operatives who deal with fuel burning equipment.* The maintenance practices followed in fuel burning installations are very poor; training facilities for the maintenance personnel is also needed. The training facilities available now for imparting the skills to such operatives are quite inadequate. The facilities will have to be increased several fold by first having training courses for the teachers who will man training centres and later by setting up training centres all over the country staffed by properly trained personnel. *Well designed Fuel Efficiency Training Schemes should be worked for this purpose taking advantage of the surplus engineering talents available in the country today. The Committee recommends that immediate action should be taken in this regard.*

12.6. In the agricultural sector, oil is used for pumps for lifting water and for propelling tractors; electricity is used for lifting water and for running agricultural machines. The efficiency of fuel usage for the agricultural pump sets varies widely among pumps manufactured by different manufacturers. There is need to standardise the designs and fix minimum norms of fuel efficiency for pumps to be manufactured. However, this is not of long-term significance as recommendations of this Report imply a gradual phasing out of diesel pumps in operation. *The more important R. & D. effort in the agricultural sector should be to evolve suitable design and construction norms for reducing the costs of rural electrification. Some suggestions for standardising designs and for reducing costs by using cheaper construction materials have been made in the Power Economy Committee (See Annexure XII(1)). This Committee would like to endorse their suggestions.*

12.7. In the transport sector, economy in fuel efficiency can be increased considerably by developing properly defined standards for—(i) engine exhaust smoke density; (ii) engine performance-axle ratio; (iii) vehicle body designed to conform the minimum specific requirements of streamlining; (iv) operation of engines as per designed specifications; (v) norms and code practices of preventive maintenance; and (vi) use of lube oils of proper quality. *Efforts should, therefore, be mounted with the cooperation of the various institutions* already in existence, like the Indian Institute of Petroleum, Indian Standards *Institute*, The Central Mechanical Engineering Research Institute and others, *to implement a time bound programme of increasing the efficiency of utilisation of oil in the transport sector.*

12.8. As already discussed in the Chapter on Policy for Power Sector, it is possible to increase the efficiency of use of coal in thermal power plants by technological improvements. Efficiency in the use of coal increases with the unit size of thermal power plant is as follows:

	Size of Generating Set				
	60 NW	100 MW	20 MW	3 0 MW	50 MW
Coal (average calorific value of 4500 kcal/k) required per kwh of energygeneration	0·67	0.60	0·53	0·52	0·50

The unit sizes upto 200 MW are being manufactured in the country.

12.9. The considerations on which the optimal size of the power plant has to be made have been discussed in Chapter IX. It is evident from the data that if regional grids become effective by the end of the Fifth Plan, thermal plants of unit size of 500 MW may become optimal in some regions. Development work on the manufacture of 500 MW units with indigenous know-how should be taken up immediately. Although, this task of developing individual components for such a large size plant would be time consuming and may call for large investments, it will provide an opportunity for developing the local design and development skills and would enable the country to take up the larger problems which will emerge in the power sector in future. A comprehensive survey of the problems involved in developing an indigenous 500 MW generating unit has been made and it is the considered view that the devolopment responsibility could be shared by the existing organisations in the country. *The Committee recommends that the design, development and manufacture of 500 MW generating unit should be entrusted to an Indian agency with a time bound programme to get the commercial production of such sets started in the early eighties. The Committee welcomes the initiatives already taken in his regard by NCST and the Government.*

12.10. Another process which will greatly increase the efficiency of fuel use in the power generation is the adoption of MHD (Magneto Hydro Dynamics) process. In this process, an electrically conducting gas is forced through a duct at a high speed in the presence of a transverse magnetic field. The electro-motive forces induced in the gas allow current to be extracted. This system, if made commercially workable, would offer thermal efficiency of 50 per cent or higher (as compared to 34 to 38 per cent in a conventional thermal power station). The MHD generator requires a very high electron concentration in the gas which could be achieved only with very hot combustion gases (4,000°—5,000° F) seeded with materials having low ionization potential like potassium or cesium. The commercialization of MHD therefore involves the solving of problems in the areas of electrical conductivity of coal combustion gases, materials which would function at high temperatures and corrosive environment and seed recovery and gas cleaning.

12.11. Though the fundamental problems remain unsolved inspite of the efforts of very competent research groups in several countries for over a decade, several groups in U.S.A., U.K., Japan and USSR are still continuing their efforts. U.S.S.R. has already set up a plant of 25 MW capacity operating on natural gas which is reported to be working satisfactorily. In order to investigate the potential of MHD generation in India, a study team of experts was set up by NCST which has recommended a ten-year programme of development work in this area in three phases, namely:—

(a) to conduct laboratory scale experiments at the level of 2 MW size for developing necessary scientific and technical skills and experience;

(b) to design and set up a 25 MW MHD prototype plant; and

(c) to develop design capability for a full scale commercial plant in the range of 500—1,000 MW.

12.12. Development work on MHD may prove to be a very costly and time consuming effort. *While agreeing with the strategy implied in the NCST recommendation for mounting a serious R. & D. effort of developing MHD process in India, the Committee would like to emphasize the need to concentrate work on laboratory and higher scale in the critical areas, especially those connected with the use of our high ash coals for fuel gas production and review the progress periodically before embarking on installation of higher capacity MHD units.*

12.13. It is relevant to note that several other methods of increasing fuel efficiency in power generation like the combined gas-turbine system operating on clean low calorific value coal gas are also under examination. In other countries fluidised bed technology also provides aroute for increasing the efficiency of fuel utilization in power generation by 5 per cent (i.e., reduction in fuel requirement by 6 to 15 per cent as compared to a conventional thermal station). Besides, fluidised bed technology promises to be a very efficient way of utilising our low grade coal. This process consists of combustion of coal at a temperature of 800°—900° C in a fluidised bed operating at an elevated pressure and in direct contact with the heat transfer tubes. The energy in the hot compressed product of combustion is utilised for driving both gas and steam turbines. The process is viewed with great interest in other countries in view of the ability of the boiler to 'fix' sulphur and thus prevent air pollution.* *The Committee would recommend that Research and Development in the areas relating to combined gas turbine-steam turbine plants which would increase the overall efficiency of coal utilisation in thermal power stations should be intensified. (See Chapter VII on gasification of coal).*

R & D to conserve coking coal

12.14. In Chapter V the likely demand and resource availability in respect of coking coal have been discussed. As we have large reserves of economically exploitable iron ore and as the nation's need of iron and steel will keep on increasing, the problem of conserving our coking coal is an urgent one. While immediate steps for blending of prime coking coal (which is critically short) with medium and semi-coking coals (which are available in relatively larger quantities) and adoption of new steel melting technologies like fuel injection and oxygen lancing will help in extending the resources to a slightly longer period, the long term solution will depend on the development of a technology to convert non-coking coals to coal with properties which can be used in metallurgical industries. Several processes for this are under development in various countries. The formed coke process which has been developed in Central Fuel Research Institute shows good promise. Pilot plant stage work has been completed and a semi-commercial plant has also been approved.† This project should be treated as an R. & D. project and the products manufactured in this project should be subject to intensive trials in blast furnances. *The Committee recommends that a time-bound programme for the development of the formed coke process based on non-coking coals from different coalfields of India should be drawn up and the project carefully followed up.* Besides conserving the coking coal reserves, the development of formed coke for commercial use in the steel industry would enable the dispersal of the steel melting capacity in the country as our iron ore reserves and non-coking coal reserves are more widely dispersed than our coking coal reserves.

Secondary conversion processes in oil industry

12.15. As indicated earlier (See Chapter VIII) India's requirement of oil products will be rising rapidly even if measures for curbing the demand in several areas suggested in this Report were implemented. One of the results of the oil policy suggested in this Report would be that the consumption of oil products in sectors where it can be replaced by coal would be severely restricted;

*"Technological and Economic Feasibility of Advanced power Cycles" by F. L. Robinson and Sigmonds, Lewis and Cruber; United Aircraft Research Laboratories to National Air Pollution Control Admn, December, 1970

† This was recommended in our earlier Report "Fuel Policy for the Seventies" May 1972 and the project was approved in August, 1973.

as such areas pertain mostly to the use of fuel oil, the pattern of consumption of oil products that would emerge would imply a relatively larger rate of growth of the middle distillates and light ends than the heavy ends. The programming exercises based on the current relative price of crude and oil products indicate that it would be economically sensible, in the coming years, to undertake secondary processing of heavy ends to convert these to middle distillates and/or light ends. For this, both hydro-cracker and catalytic cracking can be used. While catalytic cracking process has been in use in the country, we have no experience in operating hydro-cracking plants. The Committee feels that in the Fifth Plan and thereafter India will have to adopt large scale secondary processing of heavy end products in the refinery by adopting either hydro-cracking or catalytic cracking. Both technologies have their relevance and the choice would depend on the products in demand and the costs of hydrogen production in the area. It is necessary that these technologies now obtained from abroad should be developed further in the country. There is scope for modifying the process to suit the specific needs of our country in future. *It is necessary that development work on hydro-cracking be speeded up so that the designing, manufacture of suitable catalysts, construction and efficient operation of secondary processing plants could be managed with indigenous skills.*

Utilization of natural gas

12.16. As indicated in Chapter IV, the chances of finding large quantities of natural gas in areas under lease in other countries is bright. In the event of India resorting to import of LNG and using it as a source of chemicals and/or energy, certain technological preparations are necessary in the country. Inputs in this regard should be examined even now and suitable R. & D. efforts taken to cope with the tasks if the country were to face such a situation.

Conversion of coal to oil

12.17. The increasing price of crude oil from the Middle East and the diminishing ratio of proved reserves to total crude consumption has revived the interest in all developed countries in the commercialisation of converting coal to oil. Coal-oil conversion was a technological possibility known for a long time. Basically direct conversion of coal to oil is a problem of addition of hydrogen and removal of inerts such as ash, oxygen, nitrogen and sulphur. Coal contains on an average 5 per cent hydrogen as against 12 per cent in crude oil and upto 17 per cent in various other petroleum products. A derivative of coal distillation viz. tar produced at lower temperatures has approximately 8 per cent of hydrogen which is the nearest to crude and relatively easy to convert to oil products. The chemical structure of coal however is complicated and the molecules are large compared to those in oil. Therefore, the addition of hydrogen has to be done simultaneously with the splitting of the coal molecules. This could be achieved only in the presence of suitable catalysts at a very high pressure (250 to 500 atmosphere). Several coal hydrogenation processes are under investigation in developed countries. An alternative route to oil products is by the versatile 'Fischer Tropsch Synthesis' method. In this process, it is not coal but carbon monoxide and hydrogen produced by steam-oxygen gasification of coal (exactly as in the case of fertilizer production) are reacted over a catalyst upto a pressure of about 30 atmosphere. The gas has to be extremely pure. Depending on the conditions and catalyst used, it is possible to produce a wide range of hydrocarbons and chemicals.

12.18. Though several organizations have been doing research and development work for a number of years the only commercial scale plant to produce oil from coal is operated by Sasol in the Republic of South Africa. This plant is based on the Fischer Tropsch process and its important products are gasoline, diesel fuels and waxes. During the Second World War, Germany produced 4 million tonnes of oil by the hydrogenation of coal and tar; after the war, these plants were first adapted to process petroleum residues and later even the adapted units were abandoned gradually as they became uneconomic.

12.19. At different periods, the Government of India have investigated the feasibility of production of oil from coal. At the instance of late Sir J. C. Ghosh, M/s. Koppers Corporation of USA and M/s. Lurgi had carried out separate studies in 1948. The results of these studies indicated that possibly the optimum results could be obtained by combining hydrogenation with 'Fischer Tropsch Synthesis'. A site was chosen in the Raniganj coalfield for production of domestic coke, hydrogenation of tar and F.T. Synthesis using the char fines. The project envisaged an investment of $ 7.2 million in 1949 for production of 150,000 tonnes of tar hydrogenation and chemical products annually. But the investment was deferred. In 1955, another Committee again under Dr. Ghosh, went into the problem of conversion of coal to oil, taking into consideration the changed pattern of demand for oil products. In the earlier studies, aviation gasoline and motor gasoline were primary objectives. In the 1955 study, middle distillates became the primary objective. The Committee came to the conclusion that combination of tar hydrogenation with domestic coke production could be the most economic approach. Again investment was deferred. In 1958, CFRI made a further study of the problems of coal conversion and updated the Ghosh Committee data. The conclusions were similar to those of 1955.

12.20. CFRI undertook research in the Sixties on hydrogenation of Assam coal. Assam coal with low ash content was found to be the most amenable to hydrogenation. In 1969, CFRI prepared a feasibility study on the potentiality of conversion of Assam coal to oil products and chemicals by hydrogenation. Although the processes are not basically very different from those used in Germany during the War, there are major changes in approach, product patterns and scale of equipment in view of major developments in high-pressure technology, gas compression and other fields of engineering and technology. The estimated cost under Indian conditions range between Rs. 150 crores to Rs. 250 crores for an annual capacity of about 1.5 million tonnes of oil products with varying degrees of secondary processing of products but without units for conversion of chemicals further downstream. Efforts to initiate work to produce oil from coal have been pursued for over two decades even in our own country, though nothing concrete has so far come out of this. Every time, the question is examined in a somewhat limited perspective and action is deferred when the final picture of the task and its dimensions are realised. *It is necessary that in the context of the latest review of our energy situation, the rising demand for oil products, the limited success in our oil exploration efforts and the increasing price as well as insecurity of obtaining oil from the international market, a well thougtout long-term programme for development of coal-oil conversion technology should be drawn up. This should be based on a review of the success achieved in following the diverse routes for coal-oil conversion by various agencies in other countries as well as in our country and the product mix that would be relevant to our long-term demand and supply situation in respect of oil products.*

12.21. The basic implications of the various possible technologies on coal-oil conversion have to be kept in view. The simplest and possibly the lowest investment route for conversion of coal to oil is pyrolysis i.e. hydrogenation of tar. But the production of tar in adequate quantities would prove a great hurdle in adopting this process. Conversion of tar to oil is approximately 80 per cent by weight (and 100 per cent by volume). To get one million tonne of oil by this route, we require 1.25 mt. of tar. Distillation of coal in any of the known processes produces only 8 to 12 per cent of tar, the higher figure being claimed for certain new processes developed abroad. To get 1.2 mt. of tar, over 10 mt. capacity for coal carbonisation and the development of market for the coke has to precede the establishment of a capacity of one million tonne of oil production based on pyrolysis of tar. Investment required for carbonisation of one million tonnes of coal may be nearly Rs. 30 crores. The process by itself therefore is not likely to be of any significance in the next two decades in supplementing of oil availability.

12.22. Coal hydrogenation can be effected in two ways—

(a) by solvent refining of coal with minimum hydrogenation, yielding an ash and sulphur free heavy end oil products or

(b) pressure hydrogenation of coal (variation of Berjius or Pott-Boche process) already studied by CFRI and advocated for Assam coals.

The former process has been studied in U.S. mostly to obtain pollution free fuel for power stations.

The process investigated by CFRI involves the conversion of 2 to 3 tonnes of coal to a tonne of liquid fuels. Here the major element of the investment costs are those for producing hydrogen and for setting up pressure vessels. The process also calls for good quality coals with ash content not exceeding 15 per cent with low oxygen and moisture content and having as much vitrinite as possible. Assam coals and next the Raniganj coals are found to be the most suitable. Other coals, though not impossible to be hydrogenated will involve higher costs due to lower conversion yields.

Fischer Tropsch process has the advantage that it can use even inferior grade coals containing 30—35 per cent ash. Over 70 per cent of the investment costs are for generation and purification of synthesis gas. But the process would require 5.6 tonnes of coal per tonne of liquid product (inclusive of coal for power generation, it may require 8 to 9 tonnes). The process is also a heavy consumer of water. The capital costs for F.T. process plants may be of the same order as the coal hydrogenation plant but recurring costs are likely to be higher in the case of F.T. process which may be to some extent compensated by the quality and versatility of the products obtainable in the F.T. process.

12.22. In the absence of experience on commercial scale operations in any place (other than South Africa) and the uncertainties regarding several parameters of production, it would be difficult to hazard a guess as to when and at what price of crude, the coal-oil processes would become economical in India. It is, however, likely that some of the newly developed process for conversion of coal to oil may soon prove economical if the present high prices of crude oil continue. In any case, as a measure of security for a country like India with a large potential demand of petroleum products, there is an urgent need to make a beginning as soon as possible for installing a reasonably sized unit for conversion of coal to liquid products. The studies also indicate that coal to oil process

either by Fischer Tropsch Synthesis or by coal hydrogenation can be made more attractive by designing a suitable product-mix with a substantial part in the form of chemicals of high unit value. It is relevant to note that the National Coal Board, U.K., had worked out early in 1973 a proposal for a "Coal-Plex"—concept that would convert coal into fuels and chemical feed-stocks. Steps should, therefore, be taken to create indigenous process and design capabilities and for training of personnel in all the promising coal-oil conversion processes, namely, hydrogenation through laboratory and pilot plant studies on an adequate scale. *The Committee is, therefore, of the opinion that studies should be made of the different product patterns possible using various coal-oil conversion technologies now available using different Indian coals and keeping in view the demand for the products. Demonstration plants and pilot plants of critical size should be set up to study alternative product pattern and product yield ratios and to ascertain the optimum combination of design parameters for a full size commercial plant that would suit the Indian conditions. Considering the amount of money and effort spent on the development of this technology in different developed countries, we should conciously select the areas where the R. & D. effort, in India make meaningful contribution. As there are a number of research and educational organisations engaged in the study of different aspects of chemistry, metallurgy, catalyst technology and high pressure technology which could make a contribution to this effort, the Committee recommends that a competent group should be formed to select possible areas for future work, assign this work to different organisations and to monitor the entire R. & D. effort in this direction.*

Coal gasification technology

12.23. The possibility of using coal gas in place of fuel oil in industries and in place of kerosene used in the domestic sector has been examined on several occasions. In India, we have made some progress in the use of coal (via coal gas) in place of oil products as feedstock for the nitrogenous fertilizer industry. The use of coal gas in the domestic sector has not become economically viable on account of the need to supply coal gas as a pipeline gas to each household (coal gas cannot be bottled like LPG and transported). The investment costs on the pipeline are so large that unless the volume of gas required is also large, the cost of coal-gas at the consumer end becomes comparatively higher than the costs of other fuel forms. The lack of demand for space heating, as in other developed countries, makes the domestic demand for coal gas rather viable (compared to the size of a commercially viable coal gas plant) even in big cities. However, in places like Bombay, which are separated from the nearest coalfields by the Western Ghats which increase the cost of the movement of coal by rail, there may be a case for transporting coal gas by pipeline, provided full advantage of such economies as are available in coal gas transportation could be derived by converting a large number of oil-product users to the use of coal. Coal can be gasified into Synthetic Natural Gas (SNG) on the pithead and transported as gas to Bombay where all the energy users like Industry, Power Houses and Domestic consumers could be made to use SNG as a primary fuel for all their energy needs. This could become economical in the eighties if planning is done from now on. The adoption of this possibility will depend on our developing SNG gasification and transportation techniques suitable for Indian coal and conditions. The number of gasification techniques like Hygas, Bigas and Synthene process, etc., have been developed in other countries. We should make an evaluation of the suitability of these processes in the Indian conditions and develop the particular gasification route that would be to our best advantage. *The Committee therefore recommends that R. & D. work on coal gasification and pipeline transport of coal gas should be undertaken from now on.* (*See Chapter VII on gasification of coal*).

R & D for domestic sector fuel supply

12.24. In the domestic sector the long-term need of energy can be met at the minimum social cost by increasing the efficiency of fuel utilisation in the domestic hearth, by reducing the level of use of oil products as well as forest fuels and substituting in their place cheap domestic fuels derived from coal. Studies conducted by the Indian Institute of Petroleum and the Central Fuel Research Institute indicate that significant economies are possible in the consumption of kerosene or soft coke in the domestic sector by merely changing the design parameters of the cooking appliances currently used. In view of the very large quantities of commercial fuels as well as non-commercial fuels used in the domesic sector, *it is necessary to immediately chalk out a comprehensive programme for intensive development work in the optimisation of design of cooking and heating appliances manufactured in the country.* This programme should be implemented by a Group consisting of the Indian Institute of Petroleum, Central Fuel Research Institute, Indian Standards Institution and representatives of the manufacturers of domestic appliances.

12.25. The substitution of kerosene by coal is possible if coal is refined to a solid domestic fuel or gasified and supplied as pipeline gas or converted into a liquid. The possibilities of use of coal gas in the domestic sector has been discussed earlier. The substitution of kerosene by solid domestic fuel may not be possible in metropolitan areas and highly urbanised areas where the consumer preference may be for fuel on tap like gas or more convenient fuel forms merely liquid fuels. There is scope for supplying a large

number of consumers in small urban towns with solid smokeless fuel in place of kerosene or firewood or charcoal. Several methods of producing solid domestic smokeless fuels have been studied in CFRI and Regional Research Laboratory, Hyderabad. Basically, these processes involve carbonisation of coal whereby the volatiles are removed from coal. The economics of the plant improves with the extent of bye-product recovery during carbonisation but the scale economy of bye-product recovery is such that this can be considered only in plants which carbonise about 1,000 tonnes of coal per day producing about 660 tonnes of domestic coke. Such a level of production can supply the fuel needs of over 9 lakh population. A plant of this size with minimal bye-product recovery will cost nearly Rs. 12 crores and the cost of production of coke based on coal at Rs. 60 per tonne will be nearly Rs. 250 per tonne. The investment requirements for a low temperature carbonisation plant to supply the requirements of one family will be around Rs. 650. The two processes developed by the Central Fuel Research Institute and Regional Research Laboratory, Hyderabad, differ somewhat as the former is heated both externally and internally whereas the latter is totally an internal heating process. The Regional Research Laboratory, Hyderabad, process gives only solid smokeless fuels while Central Fuel Research Institute process gives only solid yields both solid fuels and gas. The Committee feels that both these processes are relevant in the Indian context and that the choice of the process should depend on the requirements of a particular city or area and the quality of coal available. But the economics of these units are such that at least during the Fifth and the Sixth Plan periods, they could be used only to supply the needs of major cities with the population of over one million.

12.26. The Committee would like to emphasise the importance of developing processes for production of cheap domestic fuels which can be used in smaller towns as well as in rural areas by sections of the population which today use non-commercial fuels. A number of processes have been evolved by the CFRI like the "moving bed devolatizer" and "volatised coke process" and "briquet curing process". The plant size based on this process may be about 100 tonnes of coal throughout a day and the cost of supplying the needs of one family might come down to nearly Rs. 150 but these are based on the use of coals with low caking index. These processes are suitable for towns with a population of around one lakh, especially those which are near the coalfields where such coal is available.

R & D in saving oil in power sector

12.27. In the power sector, the use of oil as an auxiliary fuel for coal based generating plant is increasing. In these plants, fuel oil or LDO is required as an auxiliary fuel whenever there is need to light-up the boiler, support the flame during the low load operations and to stabilise the flame when there are variations in the quality of coal. The possibilities of reducing the oil requirements by better load scheduling have been discussed in Chapter IX. *Research and Development must be taken up to evolve boiler designs which will avoid the use of oil support even when the load on the boiler is as low as 20 to 30 per cent of its capacity.* It also appears possible to use a coal gasification or a producer gas plant in conjunction with the thermal plant so that gas could be used in place of oil whenever there is need for an auxiliary fuel support. Suitable design and process flow have to be developed for using coal gas in place of oil as auxiliary fuel.

R & D to save oil in industries sector

12.28. In respect of industrial boilers, there is need for developing package fluidised bed-boilers to be used in small industries who now use fuel oil in view of its compactness of design and convenience. This work can be taken up by the Public Sector power equipment manufacturers like BHEL in collaboration with the CFRI and CMERI.

R & D in nuclear power technology

12.29. The most promising long-term solution to the problem of depletion of fossil fuels appears to be the development of a commercial scale fast breeder reactor (FBR). Nuclear power plants are based on the use of heat generated while splitting the atom. But the fissile material—natural substances which readily undergo fission like Uranium 235—are known to be available in limited quantities only. The solution to the shortage of fissile material is to have nuclear reactors which simultaneously "breed" or produce fissile material while consuming some fissile material. Even the nuclear reactors of the kinds now operated produce fissle material viz., plutonium. But, in a Fast Breeder Reactor, the quantity of fissile material produced will be larger than the fissile material consumed. This is achieved by using a fuel which contains both fissile material (like U-235 or plutonium) and fertile material (like thorium) and making the fuel react under conditions in which an adqeuate number of neutrons are released which react with the fertile material and produce fissile material which more than replaces the fissile material lost in the first reaction. India is richly endowed with thorium. Once we have adequate stock of plutonium and the technology of FBR based on the use of thorium-plutonium fuel is available, we should have no shortage of indigenous nuclear fuels for a number of decades. Therefore, the strategy of our nuclear programme to produce plutonium in the heavywater type reactors which could later be used with thorium in FBRs is the appropriate one for the country. The Committee is aware of

the large problems of construction materials, anti-pollution devices and safety devices and construction costs which are yet to be resolved before FBR's could be commercially operated. Even so, considerihg that very large investments are being made in U.S.A., U.K., Germany and Japan, besides India, on the development of commercially viable FBR's, it is indicative of the general expectation that the difficulties in the construction of FBR's will be resolved very soon.

12.30. The Committee will, however, emphasise that the real success of our nuclear programme lies in developing our FBR as early as possible. The time-bound programme outlined in the nuclear plan for the seventies has not progressed as per the earlier expectations. We should not draw up a revised programme in the light of the experience gained so far and emphasise in the programme the development of FBR as central to our nuclear strategy. The Committee also recognizes the fact that once the Fast Breeder Reactor is developed, the possibilty of constructing the Fast Breeder power stations will depend on the availability of plutonium, which is produced in the first generation heavywater power stations. This makes it desirable to build an adequate number of heavy water power stations before fast breeders can pick up momentum.

Energy from waste products

12.31. Technical literature published abroad points to the possibility of production of useful energy and fuels through the efficient disposal of urban waste by incineration or exidation techniques or by pyrolysis. But adequate research has not been done in India to make an evaluation of the commercial possibilities of this process. It is necessary now to take up this work in view also of the several social advantages obtainable by the disopsal of waste products.

The concept of multiple use of cowdung to produce fuel in the form of Methane gas simultaneously with high quality manure by means of Gobar Gas Plant has been known in India for more than 30 years but the use has been inhibited by (a) high cost of the plant; and (b) inconvenience in its maintenance.

The gobar-gas plants now in use, produce about 13 standard cubic feet of gas of about 550 BTU/Sc ft. from the use of dry dung from one animal. The cost of a plant capable of using the dung from five animals is reported to be Rs. 2500 per plant.

R & D work on the following problems are necessary to make the use of Gobar Gas Plants more economical:—

(1) to work out better and cheaper plant designs using, wherever possible, local or easily available materials;

(2) to evolve cheaper designs and materials for gas holders and to improve the efficiency of burners;

(3) to evolve more effective techniques of maintenance;

(4) to understand fermentation chemistry and conditions which influence greater and preferential generation of Methane and microbial action so as to devise means of increasing gas production and maintaining gas production during winter when microbial activity tends to be slow.

R & D in non-conventional energy forms

12.32. A number of energy sources, which have not been considered of any practical significance as sources of supply of enery to mankind, have recently acquired importance in view of their renewability, pollution free production possibility and, more recently, the very high increases in oil prices. The more important among the non-conventional energy sources are solar energy, geothermal energy, wind power, tidal power and chemical energy. The energy obtained from these sources except under very special conditions and in limited quantities appears to be comparatively of much higher cost. Even in the foreseeable future—upto 1990-91 covered in this Report—the possibilities of any of these energy sources contributing any significant share of our energy needs appear remote. Even so these energy forms are likely to acquire practical significance sometime in future and *it is therefore desirable that research and development in these areas are kept up in the country.*

R & D on solar energy

12.33. The special merit of solar energy over other energy form lies in the fact that it is abundantly available all over the country and that it is inexhaustible. But this energy is available in a very dilute form—the average intensity of solar radiation is around 600 calories per square centimeter in India. If this energy is to be used for purposes for which fossil fuels or electricity are now used, solar energy as available should be concentrated by using collectors and concentrators. The high cost of solar energy in any usable forms, is due to the cost involved in setting up the collectors and concentrators and in adjusting their position to enable them to get the best impact of the solar radiation throughout the day and in all seasons of the year.

12.34. R & D in India may be concentrated on—

(a) *the development of thin-film technology to produce cooled surfaces which could be used as collectors and concentrators of solar radiation, thus reducing the costs.*

(b) *the possibilities of using solar energy to convert animal waste, agricultural waste and algae into gaseous fuels and methane.*

(c) *developing low cost solar water heaters.*

(d) *developing solar distillation and desalination units for use in arid rural areas.*

(e) *developing techniques for the optimal use of solar energy for drying and storage of grain, wood and hay and air-conditioning.*

R & D in geo-thermal energy

12.35. Geothermal energy has only limited possibilities in India (See Chapter IV). The development work relevant to our country appears to be the setting up small capacity steam turbines at Puga or other centres, where geothermal explorations are hearing completion, so as to enable collection of operational details.

R & D for using wind power

12.36. Wind-power utilisation has only limited possibilities in India. (See Chapter IV). However, further development work for installing windmills in cluster forms for pumping and power generation is recommended, as it would enable the collection of cost data required to evaluate the possibilities of wind-power utilisation. Development of 5 to 10 kW wind electricity generators could also be taken up in India.

R & D for using tidal power

12.37. The data on the extent of useful energy that could be obtained from tidal power and the costs involved in utilising this is inadequate at present. *The only further work that could be recommended at this stage is the collection of more data on tidal movements and the preparation of feasibility reports with regard to specific coastal locations.*

R & D for chemical sources of energy

12.38. There are possibilities of *developing battery powered light vehicles.* This project can be successful only through the adoption of all the latest technological advances and not by the mere replacement of existing petrol engine by an electric powerpack. Development work on this *is recommended.*

12.39. The electrification of villages which have sparse population, say below 500, and are remote from other villages has proved to be prohibitively costly and such villages have remained unelectrified so far. *Such villages can utilise fuel-cells to obtain their power needs. As fuel cell technology is still not adequately developed, further work on this will be of use.*

Priorities in the technology plan

12.40. Though research and development is possible in a number of areas as discussed above, the importance to be given to specific problems and the priorities to be assigned will depend on the likely benefit cost ratios of the different R & D options and the magnitude of energy supply saving or substitution that is possible in each option. The data available on the costs of different options and even of the state of the arts in each area is so inadequate that the Committee could not make any meaningful comparison of the possible benefit cost ratio of the different options and assign priorities. In a broad qualitative sense, we agree that the development of non-conventional energy forms is unlikely to provide any large measure of energy supply in the next two decades. Among the other options, the important ones are the following:

1. *Development of Fast Breader Reactor.*
2. *Development of Boiler Designs to reduce oil consumption in Thermal power generation plants.*
3. *Fluidised bed technology/Development of Commercial power generating plants based on this.*
4. *Development of SNG production and transport technologies suitable for Indian conditions.*
5. *Development of technologies for manufacture of cheap smokeless fuels for use in the domestic sector.*

It is of course necessary to have a competent group to coordinate the R & D efforts in the energy sector which will keep under review the progress registered in the different areas and adjust the priorities from time to time to enable the best results to be obtained.

CHAPTER XIII

SUMMARY OF RECOMMENDATIONS

Demand for energy

1. In estimating the demand for fuels the Committee took note of the "Long Term Perspective" of the Indian Economy set out in Fifth Five-Year Plan. The Committee has estimated three levels of demand for energy, viz.—

CASE—I: assuming that the relative prices of fuel will continue to be the same in future and that technology shifts would follow the same trends as in the past*;

CASE—II: assuming an intermediate level between Case-I and Case-III which is considered possible of achievement under most of the foreseeable set of conditions; and

CASE—III: assuming that the relative price of oil products and other fuels will continue to be in the same state as in the first quarter of 1974 and that the measures indicated in the report for increasing fuel efficiency and for substituting oil products by other fuels in areas which are viable and desirable on techno-economic considerations are implemented as suggested.

(paras 3.8—3.10)

Case-II has been referred to as the normal case while discussing policy issues relating to specific fuels, but the Committee's recommendations are that efforts should be made to bring the demand in line with the estimates made in Case-III. The requirements of the different commercial fuels as estimated by the Committee are indicated in the Table below:—

Consuming Sector	Coal (Millon Tonnes) CASE I	II	III	Oil Products (Million Tonnes) CASE I	II	III	Electricity (Million kWh) CASE I	II	III
1978-79									
Energy use	132·0	137·8	142·8	26·7	24·5	22·7	120	124	128
Non-Energy use ..	3·0	3·0	3·0	7·7	7·7	7·7			
Total ..	135·0	140·8	148·5	34·4	32·2	30·4	120	124	128
1983-84									
Energy use	195·0	203·8	210·4	37·0	33·2	29·9	199	205	211
Non-Energy use ..	6·0	7·0	8·0	10·8	9·4	9·0			
Total ..	201·0	210·8	218·4	47·8	42·6	38·9	199	205	211
1990-91									
Energy use	330·0	342·0	352·9	61·0	52·5	44·6	385	392	398
Non-Energy use ..	9·0	10·5	12·0	16·5	14·2	12·2			
Total ..	339·0	352·5	364·9	77·5	66·7	56·8	385	392	398

(Para 3·35)

*With certain adjustments in the trends of consumption of fuel oil, to correct for the increased use af fuel oil in the early seventies due to lack of coal supplies.

The estimates of demand for non-commercial fuels are as follows:—

Fuel	1978-79		1983-84		1990-91	
	In mt	In mtcr	In mt	In mctr	In mt	In mtcr
Firewood and Charcoal	132	125	131	124	122	116
Dung cake (dry)	65	26	65	26	53	21
Vegetable waste	46	44	46	44	46	44

(Para 3·36)

Reserves of coal

2. A summary of the total gross reserves of the different varieties of coal is given below:

Summary of reserves of coal available in India

(In million tonnes)

	Total Gross Reserves	Proved Reserves	Indicated Reserves	Inferred Reserves
1. *Cooking Coal*				
Prime cooking coal ..	5650	3650	1540	460
Medium cooking coal	9431	3850	4309	1272
Semi to weekly coking coal ..	5073	1559	2600	914
Total coking coal ..	20154	9059	8449	2646
2. *Non-cooking coal*				
Non-cooking coal ..	59968	12306	22310	26180
Tertiary coal ..	828			
3. *Lignite*				
Lignite	2025	1795	202	28
GRAND TOTAL ..	82975	23160	30961	28854

Our coking coal reserves will be able to sustain the growing requirement of the steel industry for a period of about 40 years only. On very rough calculation, it may be stated that the reserves of non-coking coal that have been categorised so far would last for about 100 to 150 years.

(paras 4.2, 4.3 and 4.4)

Oil reserve

3. In the oil prospect map of India, 27 basins have been delineated on land and off-shore covering a total sedimentary area of about 1.41 million sq km on land and about 0.26 million sq km lying with the 100 meter isobath of shelf-zone in the Indian off-shore. The well studied oil bearing area constitutes about 4 per cent of the total area of the Indian sedimentary basins which could be the habitat for oil. The proved reserves of crude oil and natural gas are shown in Table below:—

Reserve of crude and natural gas

Area	Crude Oil (In million tonnes)	Natural Gas (In billion Cubic Metres)
Gujarat	56·38	19·66
Assam	71·46	42·82
Total ..	127·84	62·48

(Paras 4·9, 4·10 and 4·12)

Hydro-electric potential

4. The economically usable hydro electric potential estimated for each of these river systems and its State-wise distribution is given in Table below:—

Statewise distribution of power potential

State	MW at 60% LF
1. Andhra Pradesh	2,476·5
2. Assam (including Meghalaya, Nagaland Mizooram)	11,599·4
3. Bihar	609·7
4. Gujarat	677·0
5. Jammu & Kashmir	3,590·5
6. Kerala	1,539·5
7. Madhya Pradesh	4,582·3
8. Madras	708·2
9. Maharashtra	1,909·6
10. Mysore	3,372·8
11. Orissa	2,062·0
12. Punjab & Haryana	1,360·5
13. Rajasthan	149·0
14. Uttar Pradesh	3,764·0
15. West Bengal	22·0
16. Himachal Pradesh	1,867·5
17. Manipur	865·0
Total ..	41,155·5

SOURCE: Central Water and Power Commission.

The Power Economy Committee expressed the view that "on the basis of the latest information regarding hydel energy resources and their economics of development, it would be possible to instal about 80 to 100 million kW of hydel capacity on our river systems during the next two to three decades......". In the absence of details this Committee has taken note of the hydel potential as indicated by CW & PC. The Committee would recommend that a more systematic delineation of our hydro-electric potential should be taken up as soon as possible.

(para 4.20)

Uranium reserves

5. The reasonably well assured uranium resources in India are about 22,000 Te U_3O_8 with an additional inferred reserves of 24,000 Te U_3O_8 Once these fast breeder reactors come on line by 1985-90, they will produce more plutonium than they would burn, and then the uranium resources available in India would be able to support about 600,000 to 10,00,000 MW of installed capacity for a life time of 30 years. Thus, the potentially available energy from the presently known uranium deposits in India would amount to amount 120×10^3 to 200×10^3 billion kWh of electricity.

(paras 4.23 and 4.24)

Energy perspective beyond 1990-91

6. The considerations described above suggest that the rate of growth of energy demand in the period beyond 1990-91 may not be as high as the projected rate of growth of energy demand upto 1990-91 and certainly not as high as the growth rates observed over the past two decades.

(para 6.11)

Regional energy policy

7. If the objective is to achieve a more balanced per capita total commercial energy consumption by 1990-91, there should be a well conceived policy towards regional development which will take note of the divergences in resource endowments. The region-wise energy policy should be a part of a well conceived regional development strategy.

(para 5.16)

Review of policy

8. It is necessary to keep the energy policy under periods review and to effect changes whereever necessary. If the energy plans and policies are to be operationally meaningful, they should be reviewed periodically at least once in three years and the planning horizon extended at each time to 15 years.

(para 6.22)

Organization to implement a coherent fuel policy

9. The implementation of the recommendations of the Fuel Policy Committee which call for coordinated action by several Ministries and agencies of the Government. An ideal organizational arrangement for this will be the setting up of an Energy Commission clothed with adequate powers and manned by suitable talents which can be entrusted with the responsibility for the periodic review of the energy situation and for planning for optimal production and distribution of the different fuels. However, it is recognised that such a Commission will have to take over the functions which are now dealt with in several Ministries like the Ministry of Irrigation and Power, the Department of Mines, the Department of Petroleum, the Railway Board and the Planning Commission. It is also to be recognised that the scope of work of the Commission will become very large and some of the problems associated with large organization will have to be faced by the Commission. The need, however, to coordinate the activities of the different agencies of Government dealing with energy is very urgent. The Committee considers that it would be appropriate to immediately set up an Energy Board consisting of the Ministers of the concerned Ministries supported by a suitably structured Secretariat to assist this Board. Such a Board would be somewhat different from a Cabinet Committee as the Board would have a Secretariat which would initiate or undertake studies and analysis relevant for the review or revision of the fuel policy and would not depend entirely on the administrative Ministries for such studies.

(paras 6.23 and 6.24)

Studies on energy policy

10. Whether a separate Institute of Energy Studies is set up or the proposed Energy Board takes up the work, the working of the agency entrusted with Energy studies, should be oriented more towards the arranging for the studies to be conducted by different institutions and agencies in existence now and coordinating the research projects. Any attempt to centralize the research efforts relating to energy problems which extend over a very large area of economics, science and technology under a single institution may prove counter-productive.

(para 6.25)

Coal Resources

11. Coal should be considered as the primary source of energy in the country for the next few decades and the energy policy of the country should be designed on this basic premise.

(para 7.4)

12. The locational aspect of the coal deposits in the country underlines the need for developing an efficient and adequate transport system which would ensure the flow of available fuel resources from the points of availability to the points of requirements.

(para 4.8)

13. As the prime coking coal resources may get exhausted in about 40 years' time and the medium coking coal after some more time, it is necessary that all efforts are taken from now on for the conservation of prime coking coal, in particular, and of coking coal, in general.

(para 7.16)

14. Detailed investigations should be aimed at providing sufficient mineable deposits for the requisite level of production related to the demand for coal estimated for 1990-91.

(para 7.14)

Production planning

15. A careful perspective of coal production should be planned on the basis of the information available and suitable action for exploitation and mine planning taken in advance in the different coalfields. This perspective plan should be followed by preparing a shelf of project reports well in advance of each plan period. The recently set up Central Mine Planning and Design Institute should participate in all activities connected with the formulation and implementation of the perspective plan for coal including exploration and investigation (in association with the Geological Survey of India and Mineral Exploration Corporation) of promising areas assessment of their potential over a period of 20 to 25 years, suggestion of priorities for development and preliminary feasibility studies of the projects.

(para 7.14)

16. Steps should be taken urgently to ensure adequate and uninterrupted power supply to the collieries and washeries.

(para 7.14)

17. Production of the different grades of coking coal in future will need to be planned in accordance with the proportion in which they are needed in the steel plants and adequate crushing and preparation facilities have to be installed in all steel plants. In future, the planning of metallurgical coal mines and the construction of steel plants should be carefully synchronised.

(para 7.17)

Coal conservation

18. There are several technical possibilities of conserving coking coal. It is necessary that research and development activities in this regard are speeded up from now on.

(para 7.18)

19. The possibility of projecting large scale mechanised open cast mines in Jharia coalfield with much higher over-burden to coal ratio needs to be studied in depth.

(para 7.20)

20. Arrangement for stowing crushed stone locally available should be made so as to permit underground mining of coal from thick seams.

(para 7.19)

Coal preparation

21. In future, there should be only three product washeries.

(para 7.21)

22. It is necessary to undertake research for evolving suitable designs for washeries which are best suited for washing Indian coal and which would reduce the cost of washing.

(para 7.22)

23. In future, there will be need to wash even non-coking coal. As the washing of non-coking coal is a costly process, other methods of improving the quality of coal like simple high specific gravity washing, hand picking of better grades and proper sizing by screening etc. should be explored and the choice of beneficiation decided with due regard to consumer requirements, available grades of coal, the scale of the required operations etc.

(para 7.26)

24. The coal industry should accept the responsibility to supply on a long-term basis the required grade of coal, if necessary, by changing the source of coal supply from time to time or by blending different grades of coal to make up the required grades.

(para 7.26)

Coal for power generation

25. The Linkage Committee should consider the loading arrangements at each end and give suitable suggestions for loading and unloading as part of the linkage.

(para 7.30)

26. The Electricity Boards should give greater attention to the problems of coal handling and storage; optimal stock levels for each plant should be worked out with reference to the source of coal supply, its distance from the power plant, reliability of the rail link, the seasonal variations in these factors and in the demand.

(para 7.30)

27. In the major power plants, it would be desirable to have arrangements for sizing and preparation of coal before feeding into the boilers as this would make it possible to deal with possible changes in the quality of coal received.

(para 7.30)

28. It is necessary to have a suitable pricing policy for the use of middlings for power generation, if such use is to increase as estimated in the Report, to about 21 million tonnes by 1990-91.

(para 7.31)

29. Meaningful plants for thermal power generation have to be drawn up from now on in a coordinated manner with the plans for coal, production, especially in respect of the southern region. The detailed investigation for coal mines

to supply the requirements of the power stations should be taken in hand immediately.

(para 7.33)

Coal Dumps for industrial consumers

30. If the increasing coal requirements of the industrial consumers is to be met satisfactorily, coal dumps will have to be set up in all the major industrial regions.

(para 7.34)

31. The setting up of coal dumps in major industrial areas will call for coordinated planning for movement of coal from the dumps to the consumer points by road alongwith the plans for moving coal from the mines to the dumps.

(para 7.49)

32. A five-fold increase in the next two decades in the requirement of coal for industries calls for detailed industrial location planning from now on and the locational plans regarding industries should be consistent with the plans for the production and movement of coal.

(para 7.35)

Coal for the domestic sector

33. A plan should be drawn up for increased movement of soft coke from the Bengal-Bihar region to the urban centres in the country.

(para 7.39)

Coal for exports

34. Separate plans for opening up export-based coal mines near the ports of Haldia and Paradeep may be drawn up, and possibilities of exporting this coal to Bangladesh and Burma and countries in the Pacific region will have to be considered without affecting domestic requirements.

(para 7.40)

Productivity

35. Studies should be initiated immediately for the optimal use and maintenance of machines and for training coal mines workers in the use and maintenance of equipment.

(para 7.43)

Transport

36. The studies made by the Committee indicate that Railways constitute the most economic way of moving coal for most of the consuming classes and consumer locations in India. Adequate attention should be paid to rail transport planning in regard to development of additional line capacity, yard capacity and signalling and communication which would facilitate speedier turn-round of wagons as well as augmentation of the wagon fleet.

(para 7.45)

37. Serious consideration should be given to the problems of coal movement in the Bengal-Bihar area and for removal of the factors which limit the capacity in the Bengal-Bihar region for movement in specific sections towards the northern, western and southern regions.

(para 7.46)

38. The Central Water and Power Commission should prepare a feasibility study for the transportation of coal by pipeline for a super thermal power station of more than 1,000 MW capacity.

(para 7.51)

Use of inland waterways

39. It would be useful to make a careful study of the techno-economic feasibility of transport by river to selected towns like Varanasi. Allahabad etc. We would, however, emphasise that for the scheme to be successful, large scale river training schemes will have to be taken in hand and a navigable channel marked throughout the course. Aids for night navigation may also have to be provided if the turn-round-time has to be kept within economic limits.

(para 7.52)

Coal gasification

40. It is difficult to foresee any large size gas plants located at the pithead transporting gas for industrial or domestic users far away from cities; but in major cities like Bombay and Calcutta, gas plants located near the cities with smaller capacities may be a viable proposition.

(para 7.57)

41. Research and development should be continued on the techno-economic aspects of gasification and specific possibilities should be investigated for using poor quality coal for gasification and for use in industrial locations

(para 7.58)

Machinery

42. A Committee of representatives of the concerned Departments and organisations should make an assessment of the indigenous capacity for the manufacture of coal mining machinery, suggest increases in capacity and fix import requirements for the period till the indigenous capacity catches up with the demand. This Committee should also take up the task of standardising the equipment. It may be made obligatory for the equipment manufacturers to produce a certain quantity of spares for the machines every year.

(para 7.60)

Choice of technology

43. The selection of the optimal technology should be made on economic grounds using appropriate weightages for machine utilisation un-

der Indian conditions and for the availability of abundant labour force.

(para 7.61)

Lignite

44. It is strongly recommended that the second mine cut at Neyveli be taken up and the capacity of the power plant be increased to 800 MW.

(para 7.62)

45. The possibility of manufacturing bucket wheel excavators in the country should be examined and the manufacture of the required number of excavators taken up in a coordinated manner

(para 7.64)

46. In view of the location of Neyveli lignite deposit in relation to other fuel sources, inspite of the heavy investment, the Committee is inclined to recommend the opening of additional mines at Neyveli and increasing ths production to a level of about 20 mt.

(para 7.65)

OIL

Oil Policy

47. India's Oil Policy should be based on an understanding of the international oil situation. It should be designed with the specific objectives of:

(a) reducing the quantity of oil products to be imported·

(b) reducing the total foreign exchange expenditure, and

(c) improving the security of supplies of crude and oil products required from sources outside the country.

(paras 8.10 and 8.17)

Oil Exploration

48. Oil exploration in India should be given priority attention. The exploration activities particularly in the off-shore areas and selected on-shore areas should be speeded up. There is urgent need to augment the capabilities of the ONGC by providing them with more modern equipment.

(para 8.27)

49. The following steps may have to be taken in oil exploration:

(i) Expedite the exploratory drilling in the Bombay High region.

(ii) Undertake a large volume of exploration drilling operations in the Tripura and Cachar areas and in the South-Eastern border of the Upper Brahmaputra Valley.

(iii) Re-survey some already explored portion of the Cambay basin and the Upper Brahmaputra Valley region of the Assam-Arakan Basin using sophisticated geophysical techniques, and intensive exploration drilling operations in such portions, to locate additional traps in particular stratigraphics which might have been missed in the course of the exploration work conducted earlier.

(iv) Extend the exploration operations to the portions of the Cambay Basin and the Upper Brahmaputra Valley region of the Assam-Arakan Basin which had not been explored so far.

(v) Conduct extensive seismic surveys in all the areas and follow up the results by drilling of exploration wells. Poriority to be assigned to the continental shelf in the Arabia Sea adjoining the area already covered, the continental shelf area south of Sunderbans and the continental shelf area of the Andaman Islands.

(vi) Test by deep drilling already known structures in the Shiwalik foot hill belt of Jammu and Kashmir, Punjab and Himachal Pradesh.

(vii) Intensify the exploration work, including seismic surveys and drilling operations, in the Ganga valley in West Bengal, Saurashtra and Jaisalmer area.

(vii) Intensify the exploration work, including commencement of exploration drilling, in the land area of Andaman and Nicobar Islands.

(para 4.15)

50. All attempts should be made to take advantage of the complementaries of the resource endowments of India and the oil exporting countries and meaningful bi-lateral arrangements including participation in crude production in other countries entered into.

(para 8.27)

Crude stocking

51. With a view to providing an insurance against short-run breakdown in the supply of crude to the country, there is need for building up a stock of crude within the country. We should explore various ways of building up our stocks consistent with our resources.

(para 8.30)

Refinery planning

52. In each plan period, there should be a careful examination of the refinery locations, the product mix required in each refinery, the extent

of secondary process to be established and the feedstock choice in the fertilizer industry.

(para 8.25)

Oil products supplies and pricing

53. While the potential for export of oil products should be kept in view, adequate care should be taken to analyse the long-term prospects for the product before investment options are approved.

(para 8.29)

Naphtha

54. Since light distillates will be in short supply right upto 1990-91, Naphtha demand will have to be regulated by proper licensing of fertilizer and petrochemicals projects and it will be necessary to price the naphtha product within the country appropriately.

(para 8.32)

HSDO

55. The price of HSDO and kerosene should continue to be kept at par with each other. If, at any time, it becomes necessary to tax the consumers of HSDO and kerosene at different rates, tax should be levied on the consumers of HSDO by suitable levies on other products which they use like tyres, tubes or spare parts.

(para 8.39)

Road-Rail coordination

56. The Committee recommends that immediate action be taken to coordinate the road and rail transport in an optimal manner in order to manage the HSDO demand to levels indicated in the report. Long distance movement of commodities by road should be discouraged while simultaneously increasing the capability of rail transport.

(para 8.35)

Dieselization in railways

57. It has been estimated that 1,800, 3,000 and 4,000 Km of railway track will be electrified during the Fifth, Sixth and the Seventh Plan periods, which would take the total electrification to 12,800 Kms. With electrification of track increasing to that extent, it is anticipated that the railways can maintain the stock of diesel locomotives at a constant level of about 2,600 (which will be reached by 1978-79) and the consumption of diesel at 0.8 mt per year from then on. In other words, diesel consumption which was 0.5 mt in 1970-71 will increase to 0.8 mt by 1978-79 and stay at that level from then on. Though the stock of diesel locomotives will remain the same from 1978-79 onwards, the areas in which they operate will change from time to time. The diesel traction will be introduced in the areas where the steam traction will be unable to handle the increasing load traffic but electricity could not be extended for want of adequate traffic.

(para 8.37)

Fuel Oil

58. Fuel oil being a valuable raw material for the production of high cost petroleum products which have good export potential or can serve as import substitutes, large quantities of it should be earmarked for the production of high value products like lubes, bitumen, petroleum coke and wax.

(para 8.39)

59. The Committee recommends that even at the stage of licensing new industries, the use of fuel oil in furnaces should be prohibited and the nationalised coal industry should be asked to take immediate steps to set up coal dumps in all the industrial centres of the country.

(para 8.39)

60. The Committee recommends that the Government should take immediate steps to improve the design of indigenous thermal equipment with the speciffc objective of reducing the technological requirements of oil in the thermal plants.

(para 8.40)

Coal and fuel oil as fertilizer feedstock

61. The Committee is of the view that new fertilizer projects should be designed to make use of coal as the feedstock. However, in the refineries, even when the surplus heavy-end products are subjected to secondary processing, there will be some quantities of heavy residual material which cannot be used for any purpose except for burning as a feedstock for fertilizer production. Such material should be used as feedstock in preference to their use as fuels.

The Committee is of the view that even if in view of the lack of operating experience of large scale fertilizer production based on coal and the need to complete quickly a few more fertilizer projects within the country to meet the shortage of fertilizer a few projects based on fuel oil are taken up during the Fifth Plan, these projects should have adequate provision to switch over to the use of coal at a later date.

(para 8.41)

62. Recent explorations, inland and on-shore, indicate the possibility of discovering substantial quantities of natural gas. The production of fertilizers, methanol and other chemicals based on natural gas will have to be given preference over the use of natural gas a mere fuel.

(para 8.42)

ELECTRICITY

Installed capacity

63. The installed capacity requirements for different years in future to meet the energy re-

quirements corresponding to the Case-II estimates are indicated below:

Installed capacity requirements for power generation in 1978-79, 1983-84 *and* 1990-91

Year		Forecast of energy consumption (b kWh)	Forecast of energy requirement (b kWh)	Installed capacity needed (m kW)
1978-79	..	100·3	116·4	33·6
1983-84	..	167·7	193·6	53·0
1990-91	..	320·4	370·7	87·3

* at the bus-bar, i.e ., consumption plus line losses.

NOTE: —(1) On the basis of the calculations for 0·48 plant factor and 90 per cent availability the installed capacity required in the year 1978-79 would be 30·7 million kW. However, as there is a large spillover of works from the Fourth Plan and due to bunching of new projects the capaciy coming on stream into the final year of the Fifth plan is very large. But as many of them would be operative only in the second half of the final year, only half of the benefits have been counted towards the Fifth Plan and hence the increased provision of installed capacity.

(2) For the year 1983-84, on the basis of 0·495 plant factor and 92 per cent availability the installed capacity should be 48·5 m kW. This is, however, being assumed as 53·0 m kW for reasons which are similar as in the case of 1978-79.

(3) The figure of installed Capcity has been arrived at 87·3 mkW on the basis of 0·51 plant factor and 95 per cent availability.

(para 9.32)

Power system planning

64. The Committee would strongly recommend that rational measures should be initiated in planning and operating the power systems so as to ensure gradual improvement in the plant factors of operation of power system.

(para 9.33)

Improving load factor of operation

65. The Committee recommends that during the Fifth Plan period, efforts should be made to develop a more optimal load structure:

(1) by setting up more pumped storage schemes as such schemes would improve the system capability at minimum cost;

(2) by identifying industries which are intensive users of electricity and are also capable of organising their production schedule in such a way that their peak demand would occur during the system off-peak period and by giving to such units adequate incentive through specially designed tariff to encourage them to reorganize their production;

(3) by general pricing of the industrial tariff and agriculture tariff to provide incentive for use of more electricity during off-peak hours.

Hydro-electricity

66. In order to achieve the objective of maximising the generating capacity with the funds available and to generate cheap power, it is recommended that during the Fifth and Sixth Plans the level of new generating capacity to be added should be derived from hydro stations, both of the energy intensive and peaking categories.

(para 9.39)

67. The Committee would urge that during the Fifth Plan, a very strong effort should be made to complete as many as possible of the hydel stations under construction.

(para 9.40)

68. The Committee would strongly urge that a detailed investigation of the specific projects which could be set up to utilise the hydro-electric resources should be drawn up within the next two years and the scheduling of different hydro projects should be determined with reference to the cost of the projects, the characteristics of the projects and their locations. On this basis, a detailed hydro-electric power development programme should be drawn up for the future upto 1990-91 or even 2,000 A.D.

(para 9.42)

Nuclear power

69. The capacity of the nuclear power stations is estimated to be as follows:—

1978-79	1020 MW
1983-84	1900 MW
1990-91	8620 MW

The Committee would like to endorse the view of DAE that nuclear power capacity, if possible, should be increased to the maximum extent possible by 1990-91. It would recommend that a review of nuclear programme should be made by 1978-79 in the light of the pace of construction of nuclear power stations in the Fifth Plan period, the preparedness of the DAE in respect of desings for 500 MW nuclear power plants and the progress made by them towards the commercialisation of the Fast Breeder technology.

Source-wise possible generating capacities has been suggested as follows:—

(Million kW)

Year/ Mode of generation		1978-79	1983-84	1990-91
Hydel	..	13·00	20·00	28·40
Nuclear	..	1·02	1·90	8·62
Thermal		19·55	31·10	50·30
Total	..	33·57	53·00	87·32

NOTE: —Thermal stations include coal and lignite based power stations.

(para 9.43)

Plant size

70. The Committee would recommend that immediate studies should be undertaken to determine the optimal plant size for different regions of the country.

(para 9.47)

71. During Fifth Plan period, the design capability should be developed and operational norms for a 500 MW set should be studied by setting up an R & D plant of 500 MW capacity.

(para 9.48)

Locations

72. The Committee feels that in the overall interest of the economy and environmental considerations more and more of such power stations should be located at pit-heads. Depending on the local conditions, however, construction of power stations at load centres can be considered on merits as a special case.

(para 9.49)

Transmission

73. The Committee would very strongly urge that the schemes for setting up of regional grids and regional load despatch centres should be vigorously pursued; simultaneously procedures for the integrated planning and operation of power systems based on system studies should be introduced.

(para 9.54)

Rural electrification

74. Procedures should be found for a proper evaluation of the relative social benefit cost of electrifying different areas with reference to the ground water potential, the possibility of increasing production in that area, the other non-agricultural production that might be triggered off in the area etc. The correct approach to rural electrification should be through the formulation of an integrated rural development programme for clusters of villages in which the supply of electricity would be one of the inputs arranged by the Government.

(para 9.57)

75. The Committee recommends a proper pricing policy for the power supplies to the agricultural loads so as to encourage the consumers to use the optimal size of pumpsets and for drawing supplies during the system off-peak hours.

(para 9.58)

76. The Committee would recommend that rural electrification should be pursued on lines which would ensure the electrification of almost all houses in the villages to which electricity is extended.

(para 10.19)

Captive power generation

77. The Committee feels that in the overall national interest and in order to achieve the target through the limited resources available, the setting up of captive power stations should not be encouraged. Efforts should be made to increase the capacity of the power utility system to meet all the demands with high reliability.

(para 9.59)

Nuclear power programme

78. Apart from the necessity of getting the projects sanctioned and executed in time, the realisation of the nuclear power programme depends on uranium production. Uranium mining from other uranium deposits will have to be taken up. At the same time exploration work to locate additional uranium deposits would also be essential to meet the long-term requirements of the nuclear power programme.

(para 9.63)

79. The realisation of the projected nuclear power programme will also depend upon the indigenous industrial back up that could be built up during the next few years. The Indian manufacturers will have to develop their capabilities to produce many of the sophisticated any heavy components as well as special pumps and instruments required for the nuclear power programme.

(para 9.64)

80. The committee would recommend that, if possible, the nuclear capacity should be increased in the years beyond 1983-84. This should be based on a re-appraisal of the nuclear power programme on the lines suggested.

(para 9.69)

DOMESTIC SECTOR

Firewood

81. A fairly generous estimate of the forest fuel resources puts the availability of forest fuels in 1978-79 to be around 94 mt as against our estimate of demand of 132 mt (equivalent of 125 mtcr). The solution to this problem lies in taking up programmes of afforestation especially with wood species which are quick growing and are capable of yielding wood for fuel purposes.

(para 10.10)

82. The social forests can be a supplement to the other measures for supplying the fuel needs of the rural population. The Committee recommends that consideration be given for the programme of tree plantation on the road sides, canal sides and railway sides to increase the availability of firewood.

(para 10.11)

Cow Dung

83. The Committee would strongly recommend that all efforts should be made to intensify the

popularisation of 'Gobar Gas Plants' in suitable areas where the pattern of ownership of cattle will help in its easy implementation in view of the social benefits of the nutrient production, pollution abatement etc., possible from these plants.

(para 10.12)

Soft coke

84. The Committee urges that the possibility of setting up plants for the manufacture of solid domestic fuel to suit the requirements of different urban centres should be studied further.

(para 10.15)

85. The possibility of reducing the cost of soft coke to the consumer by subsidising the transport and trading margins or by raising the required funds through a surcharge on the price of kerosene should be examined.

(para 10.15)

86. The Committee recommends that all efforts should be made to increase the level of usage of soft coke as high as possible.

(para 10.15)

Efficiency

87. The Committee recommends that Research and Development should be undertaken on the design of heating appliances in the domestic sector and also other administrative action be taken to ensure that the appliances marketed conform to the design requirements.

(para 10.20)

Major Implication

88. The Committee would like to draw attention to the fact that the problem of substitution of non-commercial fuels by commercial fuels in the domestic sector has to be considered with due regard to the overall economic implications of the use of different fuels in this sector and the pricing and distribution policies should be based on a full understanding of the social cost of the use of different fuels.

(para 10.21)

COSTS AND PRICES

Price Policy

89. A proper price policy for the fuels will have to be based on an adequate appreciation of the production cost of each fuel over time. The price policy should take into account the interest of the producer, the consumer end the nation.

(para 11.5)

90. The Committee feels that the Government should indicate a reasonable rate of return to be fixed for the fuel industries as a whole which would serve as a guideline for any Committee which is entrusted with the task of price fixation for any fuel.

(para 11.7)

91. The Committee would like to endorse the view, taking note of the objectives of a rational price policy in the energy sector, that the price fixed for any fuel, coal, oil or electricity should be such that the particular fuel industry, as a whole, is enabled to earn a return of at least 10 per cent on the investment made in the industry.

(para 11.7)

Price Policy for coal sector

92. The Committee would recommend the following principles to govern coal prices:—

(1) Coal prices should be fixed with reference to the geographical area from which coal is mined.

(2) Price fixed for the coals produced in each area should cover the total costs of production and should yield a net return of at least 10 per cent on the capital invested in producing coal in that area.

(3) Differential price fixed for coal of different qualities should adequately reflect the value of the specific qualities to the consumer as well as the relative scarcity of coal of different qualities.

(para 11.11)

Price Policy for oil sector

93. The Committee considers that the producer price of crude produced in India should at least be equal to the long-term cost of producing crude in India and the difference between such a price and the prevailing international market price at any point of time should be collected by the Government as a tax. In effect, the refineries should get Indian crude at prices equal to the international price of similar crude.

(para 11.17)

94. The Committee considers that there is no particular advantage in maintaining the "price parity" formula for fixing ex-refinery prices, in view of producing most of the products by refining of crude within the country, in the coming years.

(para 11.19)

95. The Committee would like to suggest that there should be a serious examination of the need to continue the import parity formula for product pricing and to evaluate other possible methods of fixing prices which will best subserve the national interest.

(para 11.20)

Price policy for power sector

96. The Committee would like to emphasise the inadequate returns from electricity industry will seriously affect the power programme and recommend strongly that the electricity tariff should immediately be revised in all the States so as to give the rates of return as suggested by the Venkataraman Committee. The Committee would

like to recommend that the returns on investment in electricity should be 10 per cent in keeping with the rates of return expected from other energy producing industries. The basis of pricing suggested here should be applicable not only to State Electricity Boards but also to other power generating agencies like the Department of Atomic Energy, Central Electricity Authority, DVC etc.

(para 11.21)

97. The Committee recommends that the electricity tariff should be designed so as to discriminate adequately between the use of power during the peak periods and during off-peak periods. As the difference in the peak demand and off-peak demand is very large in this country, the tariff should include a penalty for use of power during the peak hours so that at least over a period of time the load curves of demand are flattened to a more reasonable level. This would bring about substantial savings in the investment cost in the power sector.

(para 11.22)

98. The Committee is of the view that there is generally no case for subsidizing the cost of power supply to any industry.

(para 11.23)

99. The Committee considers that the tariffs introduced earlier need correction, in view of the fact that at present when the demand for power from the agriculture sector is a substantial portion of the total demand and when there is no longer any need for a promotional campaign to encourage the use of power in the agricultural sector (except perhaps in certain selected pockets in the country). The Committee would strongly recommend that the agricultural loads should be charged with due regard to the cost of supplying power to the agricultural sector. At the same time, all measures should be taken to bring about a better utilization of the connected loads in the agricultural sector (like roastering of agricultural loads) which would enable the reduction of the cost of power supply to the agriculturists

(para 11.23)

TECHNOLOGY

Fuel efficiency

100. The Committee recommends that a National Fuel Efficiency Service with centres at the regional sector and industry levels and armed with adeqaute authority to ensure that their views on selection of fuels and on the level of efficiency are accepted by the consumers, should be instituted as early as possible.

(para 12.4)

101. The Committee would like to emphasise that, besides organisational arrangements, there is need for setting up facilities for training operatives who deal with fuel burning equipment.

(para 12.5)

102. A well-designed fuel efficiency training scheme should be worked out immediately, taking advantage of the surplus engineering talents available in the country today.

(para 12.5)

Reduction in investment costs

103. Suitable design and construction norms for reducing the costs of rural electrification and for meeting the agricultural pumpsets should be evolved.

(para 12.6)

104. Efforts should be mounted with the co-operation of the various institutions to implement a time-bound programme of increasing the efficiency of utilisation of oil in the transport sector.

(para 12.7)

105. The Committee recommends that the design, development and manufacture of 500 MW generating unit should be entrusted to an Indian agency with a time-bound programme to get the commercial production of such sets started in the early Eighties.

(para 12.9)

106. While agreeing with the strategy implied in the NCST recommendation for mounting a serious R & D effort for developing MHD process in India, the Committee would like to emphasise the need to concentrate work first on laboratory and higher scale in the critical areas.

(para 12.12)

107. The Committee would recommend that research and development in the areas relating to combined gas turbine-steam turbine plants which would increase the overall efficiency of coal utilisation in thermal power stations should be intensified.

(para 12.13)

108. Research and development must be taken up to evolve boilers designs which will avoid the use of oil support even when the load on the boiler is as low as 20 to 30 per cent of its capacity.

(para 12.27)

Conservation of coking coal

109. The Committee recommends that a time-bound programme for the development of a formed coke process based on non-coking coals should be drawn up and the project should be carefully followed.

(para 12.14)

Secondary conversion processes

110. Development work on hydro cracking should be speeded up so that the designing, manufacture of suitable catalysts, construction and efficient operation of secondary processing plants could be managed with indigenous skills.

(para 12.15)

Conversion of coal to oil

111. It is necessary that in the context of the latest review of our energy situation, the rising demand for oil products, the limited success in our oil exploration efforts and the increasing price as well as insecurity of obtaining oil from the international market, a well thoughtout long-term programme for development of coal-oil conversion technology should be drawn up. This should be based on a review of the success achieved in following the diverse routes for coal-oil conversion by various agencies in other countries as well as in our country and the product mix that would be relevant to our long-term demand and supply situation in respect of oil products.

(para 12.20)

112. A competent group should be formed to select possible areas for future work, assign this work to different organisations and to monitor the entire R & D effort in coal-to-oil conversion technology.

(para 12.22)

Coal gasification

113. The Committee recommends that R & D work on coal gasification and pipeline transport of coal gas should be undertaken from now.

(para 12.23)

114. It is necessary to immediately chalk out a comprehensive programme for intensive development work in the optimization of design of cooking and heating appliances manufactured in the country.

(para 12.24)

Non-conventional energy forms

115. Research and development in the areas of non-conventional energy should be kept up.

Solar energy

116. R & D on solar energy in India may be concentrated on—

(a) the development of thin-film technology to produce cooled surfaces which could be used as collectors and concentrators of solar radiation, thus reducing the costs;

(b) the possibilities of using solar energy to convert animal waste, agricultural waste and algae into gaseous fuels and methane.

(c) developing low cost solar water heaters,

(d) developing solar distillation and desalination units for use in arid rural areas;

(e) developing tehniques for the optimal use of solar energy for drying and storage of grain, wood and hay and air-conditioning.

(para 12.34)

Tidal power

117. The collection of more data on tidal movements and the preparation of feasibility reports with regard to specific coastal locations is recommended.

(para 12.37)

Chemical sources of energy

118. Development work on battery powered light vehicles is recommended.

(para 12.38)

119. Further work on Fuel Cell Technology for use in remote villages will be of use.

(para 12.39)

Priorities

120. Among the other options the important ones are the following:

(1) Development of Fast Breeder Reactor.

(2) Development of Boiler Designs to reduce oil consumption in thermal power generation plants.

(3) Fluidised bed technology/Development of commercial power generating plants based on this.

(4) Development of SNG production and transport technologies suitable for Indian conditions.

(5) Development of technologies for manufacture of cheap smokeless fuels for use in the domestic sector.

(para 12.40)

Coordination of R & D efforts in energy sector

121. It is of course necessary to have a competent group to coordinate the R & D efforts in the energy sector which will keep under review the progress registered in the different areas and adjust the priorities from time to time to enable the best results to be obtained.

(para 12.40)

Annex Table II-1

(Referred to in Chapter II)

SECTORWISE CONSUMPTION OF COMMERCIAL ENERGY FOR THE PERIOD 1953-54 TO 1970-71

In Million Tonnes of Coal Replacement and Coal Equivalent

Sector	1953-54 Coal	Oil Products in c.r.	Oil Products in c.e.	Electricity	Total Commercial Energy in c.r.	Total Commercial Energy in c.e.
1. Mining and Manufacturing	13·80	3·65	1·12	5·00	22·45	19·92
2. Transport	12·10	8·76	2·70	0·60	21·46	15·40
3. Domestic	2·20	9·79	3·01	0·70	12·69	5·91
4. Agriculture	..	1·61	0·5	0·20	1·81	0·70
5. Commercial/Government and Others ..	0·60	..	..	1·10	1·70	1·70
Total ..	28·70	23·81	7·33	7·60	60·11	43·63
Percentage of total in. c.e. ..	65·78		16·80	17·42		100·00
Percentage of total in c.r. ..	47·75	39·61		12·64	100 00	

Source :—

The details for the period 1953-54 to 1961-62 are taken from the report of the Energy Survey of India Committee. For the period 1961-62 to 1970-71, the figures are obtained from the Energy Survey Division of the Planning Commission.

Sector-wise consumption details are not available after 1970-71.

NOTE : (1) Figure of coal does not include coal for power generation.

(2) Figure of oil products consumption does not include oil used for non-energy uses.

(3) While attempting to calculate sector-wise fuel used for the years 1971-72 ownards, it was noted that the oil used for tractors in agricultural sector is counted in the transport sector. Similarly H.S.D.O used for lifting water in agricultural sector has not been counted in agricultural sector. As it is difficult at this stage to estimate the use of oil products in agricultural sector for all previous years, corrections are not attempted at this stage.

(4) From the year 1961-62, part of the kerosene has been used in the transport sector in place of H.S.D.O. to take advantage of the low consumer price of kerosene relative to the price of H.S.D.O.

Sector		Coal	Oil Products in c.r.	Oil Products in c.e.	Electricity	Total commercial Energy in c.r.	Total commercial Energy in c.e.
				1954-55			
1. Mining and Manufacturing		13·80	4·24	1·30	5·60	23·64	20·70
2. Transport		11·70	9·36	2·88	0·60	21·66	15·18
3. Domestic		2·40	10·54	3·24	0·80	13·74	6·44
4. Agriculture		..	1·63	0·50	0·20	1·83	0·70
5. Commercial/Government and Others		0·60	..	..	1·20	1·80	1·80
Total		28·50	25·73	7·92	8·40	62·67	44·82
Percentage of Total	in c.e.	63·59		17·67	18·74		100·00
	in c.r.	45·48	41·12	-	13·40	100·00	
				1955-56			
1. Mining and Manufacturing		13·30	4·70	1·45	6·30	24·30	21·05
2. Transport		12·30	10·37	3·19	0·70	23·37	16·19
3. Domestic		2·50	13·51	4·16	0·80	16·81	7·46
4. Agriculture		..	1·72	0·53	0·30	2·02	0·83
5. Commercial/Government and Others		0·70	..	..	1·30	2·00	2·00
Total		28·80	30·30	9·33	9·40	68·50	47·53
Percentage of Total	in c.e.	69·59		19·63	19·78		100·00
	in c.r.	42·04	44·23		13·73	100·00	
				1956-57			
1. Mining and Manufacturing		13·40	5·05	1·55	6·90	25·35	21·85
2. Transport		13·70	11·51	3·54	0·70	25·91	17·94
3. Domestic		2·90	12·70	3·91	0·90	16·50	7·71
4. Agriculture		..	1·90	0·34	0·30	2·20	0·64
5. Commercial/Government and Others		0·70	..	..	1·40	2·10	2·10
Total		30·70	31·16	9·34	10·20	72·06	50·24
Percentage of Total	in c.e.	61·11		18·59	20·30		100·00
	in c.r.	42·60	43·24		14·6	100·00	
				1957-58			
1. Manufacturing		16·60	5·54	1·70	7·70	29·84	26·00
2. Transport		14·70	12·94	3·98	0·60	28·44	19·48
3. Domestic		2·80	18·28	4·09	1·10	17·18	7·99
4. Agriculture		..	2·17	0·67	0·60	2·77	1·27
5. Commercial/Government and Others		0·50	..	..	1·60,	2·10	2·10
Total		34·60	33·93	10·44	11·80	80·33	56·84
Percentage of Total	in c.e.	60·87		18·37	20·76		100·00
	in c.r.	43.07	42·24		14·69	100·00	
				1958-59			
1. Mining and Manufacturing		17·60	5·95	1·83	8·80	32·35	28·23
2. Transport		14·80	14·14	4·35	0·80	29·74	19·55
3. Domestic		3·10	13·69	4·21	1·20	17·99	8·51
4. Agriculture		..	2·35	0·72	0·60	2·95	1·32
5. Commercial/Government and Others		0·60	..	..	1·80	2·40	2·40
Total		36·10	36·13	11·11	13·20	85·43	60·41
Percentage of Total	in c-e.	59·76		18·39	21·85		100·00
	in c r.	42·26	42·29		15·45	100	

Sector		Coal	Oil Products in c.r.	Oil Products in c.e.	Electricity	Total Commercial Energy in c.r.	Total Commercial Energy in c.e.
				1959-60			
1. Mining and Manufacturing ..	..	16·80	6·44	1·98	10·30	33·54	29·08
2. Transport	..	15·20	15·53	4·78	0·90	31·63	20·88
3. Domestic	..	3·00	15·52	4·78	1·40	19·92	9·18
4. Agriculture	..	..	2·58	0·79	0·70	3·28	1·49
5. Commercial/Government and Others.	..	0·70	..	..	2·10	2·80	2·80
Total	..	35·70	40·07	12·33	15·40	91·17	63·43
Percentage of Total	in c.e. ..	56·28		19·44	24·28		100·00
	in c.r. ..	39·16	43·95		16·89	100·00	
				1960-61			
1. Mining and Manufacturing ..	..	20·90	7·23	2·22	11·60	39·73	34·72
2. Transport	..	16·00	17·37	5·34	0·80	34·17	22·14
3. Domestic	..	2·80	16·52	5·08	1·50	20·82	9·38
4. Agriculture	..	..	2·74	0·84	0·80	3·54	1·64
5. Commercial /Government and Others	..	0·70	..	..	2·20	2·90	2·90
Total	..	40·40	43·86	13·48	16·90	101·16	70·73
Percentage of Total	in c.e.	57·03		19·04	23·88		100·00
	in c..r	39·94	43·36		16·70	100·00	
				1961-62			
1. Mining and Manufacturing ..	..	24·20	7·69	2·37	14·46	46·35	41·03
2. Transport	..	16·70	19·47	5·99	0·58	36·75	23·27
3. Domestic	..	2·80	18·43	5·67	1·70	22·93	10·17
4. Agriculture	..	..	2·92	9·00	0·99	3·91	1·89
5. Commercial/Government and Others	..	0·40	..	..	1·64	0·24	2·04
Total	..	44·10	48·51	14·93	19·37	111·98	78·40
Percentage of Total	in c.e. ..	56·25		19·04	24·71		100·00
	in c.r. ..	39·38	43·32		17·30	100·00	
				1962-63			
1. Mining and Manufacturing ..	..	28·00	9·33	2·87	16·50	53·83	47·37
2. Transport	..	17·40	21·78	6·70	0·90	40·08	25·00
3. Domestic	..	3·20	20·25	6·23	1·92	25·37	11·35
4. Agriculture	..		3·17	0·98	1·10	4·27	2·08
5. Commercial/Government and Others	..	0·50	..	..	2·15	2·65	2·65
Total	..	49·10	54·53	16·78	22·57	126·20	88·45
Percentage of Total	in c.e. ..	55·51		18·97	25·52		100·00
	in c.r.	38·91	43·21		17·88	100	
				1963-64			
1. Mining and Manufacturing ..	..	27·00	6·56	2·02	19·13	52·69	48·15
2. Transport	..	17·40	25·35	7·80	0·76	43·51	25·96
3. Domestic	..	3·50	20·25	6·23	2·06	25·81	11.79
4. Agriculture	..	..	3·44	1·06	1·15	4·59	2·21
5. Commercial/Government and Others	..	0·70	0·61	0·19	2·11	3·52	3·00
Total	..	48·60	56·21	17·30	25·21	130·02	91·11
Percentage of Total	in c.e. ..	53·34		18·99	27·67		100·00
	in c.r.	37·38	43·23		19·39	100·00	

Sector		Coal	Oil Products in c.r.	Oil Products in c.e.	Electricity	Total Commercial Energy in c.r.	Total Commercial Energy in c.e.
				1964-65			
1. Mining and Manufacturing	..	27·20	7·15	2·20	20·92	55·27	50·32
2. Transport	..	17·40	27·51	8·46	1·00	45·91	26·86
3. Domestic	..	3·40	21·66	6·66	2·25	27·31	12·31
4. Agriculture	..	..	3·44	1·06	1·40	4·84	2·46
5. Commercial/Government & Others	..	0·30	0·65	0·20	2·19	3·14	2·69
Total	..	48·30	60·41	18·58	27·76	136·47	94·64
Percentage of Total	in c.e. ..	51·04	..	19·63	29·33		100·00
	in c.r.	35·39	44·27		20·34	100·00	
				1965-66			
1. Mining and Manufacturing	..	30·10	8·09	2·49	22·62	60·81	55·21
2. Transport	..	17·30	31·26	9·62	1·16	49·72	28·08
3. Domestic	..	4·10	20·00	6·15	2·36	26·46	22·61
4. Agriculture	..	..	4·41	1·36	1·89	6·30	3·25
5. Commercial/Government and Others	..	0·30	0·85	0·26	2·53	3·68	3·09
Total	..	51·80	64·61	19·88	30·56	146·97	102·24
Percentage of Total	in c.e. ..	50·67		19·44	29·89		100·00
	in c.r. ..	35·25	43·96		20·79	100·00	
				1966-67			
1. Mining and Manufacturing	..	30·40	9·06	2·79	24·38	63·84	57·57
2. Transport	..	16·90	33·35	10·26	1·27	51·52	28·43
3. Domestic	..	4·50	20·58	6·33	2·63	27·71	13·46
4. Agriculture	..	..	5·13	1·58	2·11	7·24	3·69
5. Commercial/Government and Others	..	0·50	0·95	0·29	2·82	4·27	3·61
Total	..	52·30	69·07	21·25	33·21	154·58	106·76
Percentage of Total	in c.e. ..	48·99		19·90	31·11		100·00
	in c.r. ..	33·83	44·68		21·49	100·00	
				1967-68			
1. Mining and Manufacturing	..	33·00	9·85	3·03	26·79	69·64	62·82
2. Transport	..	16·70	35·29	10·86	1·38	53·37	28·94
3. Domestic	..	4·30	21·39	6·56	2·93	28·62	13·81
4. Agriculture	..	..	5·27	1·62	2·58	7·85	4·20
5. Commercial/Government and Others	..	0·50	1·55	0·48	3·08	5·31	4·06
Total	..	54·50	73·35	22·57	36·76	164·61	113·83
Percentage of Total	in c.e. ..	47·88		19·83	32·29		100·00
	in c.r. ..	33·11	44·56		22·33	100·00	
				1968-69			
1. Mining and Manufacturing	..	31·90	10·39	3·20	29·93	72·22	65·03
2. Transport	..	16·30	39·72	12·22	1·32	57·34	29·84
3. Domestic	..	4·30	23·76	7·31	3·18	31·24	14·79
4. Agriculture	..	..	6·85	2·11	3·46	10·31	5·57
5. Commercial/Government and Others	..	0·50	1·55	0·48	3·57	5·62	4·55
Total	..	53·00	82·27	25·32	41·46	176·73	119·78
Percentage of Total	in c.e. ..	44·25		21·14	34·61		100·00
	in c.r. ..	29·99	46·55		23·46	100·00	

Sector		Coal	Oil Products in c.r.	Oil Products in c.e.	Electricity	Total Commercial Energy in c.r.	Total Commercial Energy in c.e.
				1969-70			
1. Mining and Manufacturing ..	..	35·34	9·36	2·88	32·34	77·04	70·56
2. Transport	..	16·12	43·35	13·34	1·45	60·92	30·91
3. Domestic	..	4·80	25·55	7·86	3·49	33·84	16·15
4. Agriculture	..		4·54	1·40	3·77	8·31	5·17
5 Commercial/Government and Others	..	0·40	7·26	2·23	3·97	11·63	6·60
Total	..	56·66	90·06	27·71	45·02	191·74	129·39
Percentage of Total	in c.e. ..	43·79		21·42	34·79		100·00
	in c.r. ..	29·55	46·97		23·48	100·00	
				1970-71			
1. Mining and Manufacturing ..	..	31·07	10·90	3·35	34·35	76·32	68·77
2. Transport	..	15·91	47·23	14·53	1·48	64·57	31·87
3. Domestic	..	4·07	27·58	8·49	3·83	35·48	16·39
4. Agricultur	..	..	4·51	1·39	4·54	9·05	5·93
5. Commercial/Government and Others	..	0·30	6·97	2·14	48·50	11·77	6·94
Total	..	51·35	97·19	29·90	48·65	197·19	129·90
Percentage of Toral	in c.e. ..	39·53		23·02	37·45		100·00
	in c.r. ..	26·04	49·29		24·67	100·00	

Annex Table II-2

TOTAL CONSUMPTION OF COMMERCIAL ENERGY FUEL-WISE IN ORIGINAL UNITS

Year			Coal in Million Tonnes	Oil in Million Tonnes	Electricity in Billion kWh
1953-54	..	..	28·70	3·66	7·60
1954-55	..	..	28·50	3·96	8·40
1955-56	..	..	28·80	4·66	9·40
1956-57	..	..	30·70	4·67	1·20
1957-58	..	..	34·60	5·22	11·80
1958-59	..	..	36·10	5·55	13·20
1959-60	..	..	35·70	6·16	15·40
1960-61	..	..	40·40	6·74	16·90
1961-62	..	..	44·10	7·46	19·37
1962-63	..	..	49·10	8·39	22·57
1963-64	..	..	48·60	8·65	25·21
1964-65	..	..	48·30	9·29	27·76
1965-66	..	..	51·80	9·94	30·56
1966-67	..	..	52·30	10·62	33·21
1967-68	..	..	54·50	11·28	36·76
1968-69	..	..	53·00	12·66	41·46
1969-70	..	..	56·66	13·85	45·02
1970-71	..	..	51·35	14·95	48·65

NOTES :—

1. Coal consumption figures exclude coal used in power generation.

2. Oil consumption figures exclude oil used in power generation and refinery boiler fuel.

Annex Table II-3

TOTAL CONSUMPTION OF COMMERCIAL ENERGY FUEL-WISE IN MILLION TONNES OF COAL REPLACEMENT

Year		Coal	Oil	Electricity	Total
1953-54	..	28·70	23·81	7·60	60·1
1954-55	..	28·50	25·77	8·40	62·7
1955-56	..	28·80	30·30	9·40	68·5
1956-57	..	30·70	31·16	10·20	72·2
1957-58	..	34·60	33·93	11·80	80·3
1958-59	..	36·10	36·13	13·20	85·4
1959-60	..	35·70	40·07	15·40	91·2
1960-61	..	40·40	43·86	16·90	101·2
1961-62	..	44.10	48·51	19·37	108·1
1962-63	..	49·10	54·53	22·57	126·2
1963-64	..	48·30	56·21	25·21	130·0
1964-65	..	48·20	60·41	27·76	136·4
1965-66	..	51·80	64·61	30·56	147·0
1966-67	..	52·30	69·07	33·21	154·5
1967-68	..	54·50	73·35	36·76	164·6
1968-69	..	53·00	82·27	41·46	176·8
1969-70	..	56·66	90·06	45·02	191.7
1970-71	..	51·35	97·19	48·65	1 97·

Annex Table II-4

COAL CONSUMPTION DIRECT AND INDIRECT 1953-54 TO 1970-71

(Million Tonnes)

Year			Consumption of Coal		
			Direct use	Power Stations	Total
1953	..	..	28·7	3·1	31·8
1954	..	..	28·5	3·3	31·8
1955	..	..	28·8	3·7	32·5
1956	..	..	30·7	4·0	34·7
1957-58	..	..	34·6	4·6	39·2
1958-59	..	..	36·1	5·1	41·2
1959-60	..	..	35·7	5·8	41·5
1960-61	..	..	40·4	6·7	47·1
1961-62	..	..	40·2	7·2	47·4
1962-63	..	..	49·1	8·0	57·1
1963-64	..	..	48·6	9·8	58·4
1964-65	..	..	48·2	10·5	58·7
1965-66	..	..	51·8	12·4	64·2
1966-67	..	..	52·3	13·0	65·3
1967-68	..	..	54·5	14·7	69·2
1968-69	..	..	53·0	15·4	68·4
1969-70	..	..	56·6	17·1	73·7
1970-71	..	..	51·4	17·1	68·5

Annex Table II-5

ELECTRICITY GENERATION AND CONSUMPTION (MILLION kWh) (1953-54 TO 1970-71)

Year		Sourcewise Electricity Generated				Electricity consumed
		Hydel	Thermal (coal & oil)	Nuclear	Total	
1953-54	..	2,914	3,783	..	6,697	5,597
1954-55	..	3,237	4,285	..	7,522	6,253
1955-56	..	3,742	4,850	..	8,592	7,111
1956-57	..	4,295	5,367	..	9,662	7,959
1957-58	..	5,072	6,297	..	11,369	9,430
1958-59	..	5,848	7,146	..	12,994	10,719
1959-60	..	7,207	8,006	..	15,033	12,407
1960-61	..	7,837	9,100	..	16,937	13,953
1961-62	..	9,814	9,855	..	19,669	16,448
1962-63	..	11,805	10,559	..	22,364	18,679
1963-64	..	13,597	12,861	..	26,818	21,794
1964-65	..	14,799	14,764	..	29,536	24,219
1965-66	..	15,225	17,765	..	32,990	26,735
1966-67	..	16,734	19,641	..	36,375	29,128
1967-68	..	18,658	22,537	..	41,195	32,737
1968-69	..	20,723	26,710	..	47,433	37,352
1969-70	..	23,046	27,[illegible]04	1,369	51,989	41,062
1970-71	..	25,248	28,162	2,417	55,8[illegible]7	43,724

Annex Table III-1

COAL REQUIREMENTS OF THERMAL POWER STATIONS (1978-79, 1983-84 AND 1990-91)

	1978-79	1983-84	1990-91
1. Estimated generation of electricity (b.kWh) ..	134*	205	39
2. Hydel contribution (b.kWh)	48	75	135
3. Thermal power to be generated in b.kWh ..	86	130	257
4. Contribution in b. kWh ..			
(i) from Nuclear power stations			
(a) 1020 MW (5000 hrs/yr)	5	..	..
(b) 1900 MW (5500 hrs/yr)	..	10	..
(c) 4000 MW (5500 hrs/yr)**	..	..	22
(ii) Lignite based power station			
(a) 500 MW (4000 hrs/yr)	2	..	..
(b) 1,000 MW (4,000 hrs/yr)	..	4	..
(c) 1400 MW (5000 hrs/yr)	..	..	7
5. Coal based generation in b. kWh	79	116	228
6. Coal requirement in m tonnes			
(a) Actual consumption for 22·5 b. kWh generated in 1970-71	14·5	14·5	14·5
(b) For 56·5 b. kWh additioanl power in 1978-79@ 0·6 kg/kWh ..	33·9	33·9	33·9
(c) For 37·0 b. kWh additional power in 1983-84 @0·575 kg/kWh ..	—	21·3	21·3
(d) For 112 b. kWh additional power to be generated in 1990-91 @0·55 kg/kWh	..	..	61·6
7. Total coal requirement in m. tonnes	48·4	69·7	131·3
	Say 48	70	131
8. Addl. requirement on account for inferior quality coal in m. tonnes ..	5	10	13
9. Total (m. tonnes of coal) ..	53	80	144
10. Of 9, supply as middling ..	5	12	21
11. Requirement of coal (9-10)	48	68	123

NOTE :—

*Though the generation requirement is only 120 b kWh as per the Draft Fifth Plan, in order to provide for the fact that energy potential and demand in different regions vary widely, 130 b. kWh has been taken as the plan for power generation. In our calculation this addl. 10 b. kWh has been added to the estimates in all the three cases.

**The nuclear power generation programme envisages a capacity of 8620 MW to be in operation by 1980-91. But this lower figure here has been assumed to provide a cushion against possible short falls ivarious modes of generation.

Annex Table III-2

ESTIMATED DEMAND FOR COKING COAL AND BLENDABLE COAL IN INDIA IN 1978-79, 1983-84 AND 1990-91

(In million tonnes)

	1978-79	1983-84	1990-91
1. Hot metal production ..	14·3	22·3	36·0
2. Coke rate per thousand tonnes of hot metal ..	0·85	0·85	0·85
3. Sized coke requirement ..			
(a) for Iron & Steel Industry ..	12·6	19·0	30·6
(b) for engineering foundry and other industries	3·0	4·5	8·0
Total ..	15·6	23·5	38·6
4. Equivalent gross coke (add 15% to 3)	17·25	27·0	44·4
5. Equivalent dry coal (*Add* 33⅓% to 4)	23·0	36·0	59·0
6. Raw coking coal ..	3·0	4·0	5·0
7. Raw blendable coal ..	1·7	2·0	2·0
8. Washed coking coal ..	183	29·5	49·5
9. Washed blendable coal ..	..	0·5	2·5
10. Raw coal equivalent of 8 .. (Actual of existing washeries plus input calculated at 60% yield for new washeries)	27·6	46·0	79·0
11. Raw coal equivalent of 9	..	1·0	4·0
12. Total coking coal (6+10) ..	30·6	50·0	84·0
13. Total blendable Coal (7+11)	1·7	3·0	6·0
14. Total coal to be produced which would be consumed as follows :	32·3	53·0	90·0
(a) for transformation to coke	22·0	36·0	59·0
(b) Middlings in power stations	6·0	12·0	21·0
(c) Rejects etc.	3·3	5·0	10·0

Annex XII-1

EXTRACTS FROM CHAPTER VI OF THE POWER ECONOMY COMMITTEE STUDY GROUP REPORT IV ON RURAL ELECTRIFICATION

Standardisation of Designs, Specifications of Materials and Equipments and Construction Practices.

A Technical Standards Committee at the national level under I.S.I. with the collaboration of C.W.P.C. and Rural Electrification Corporation, and of the manufacture of electrical equipments should be formed to work on standardisation and implementation of standards for achieving national economy. This Technical Standards Committee should bring out bulletins and books along with drawings and charts on the different aspects of rural electrification right from its conception to operation and maintenance of the completed rural electrification scheme. It should provide a standardised procedure and guides for the following:—

1. Investigation survey and system planning guide for electric distribution systems in rural areas.
2. Economic design of primary lines and sub-stations for rural distribution schemes.
3. Electric system capacity of earmarked rural areas for intensive and integrated developments.
4. Standards for the preparation of circuit diagrams and electrical data sheets.
5. Construction work plans for rural schemes.
6. Single-phase designs and guide for design and selection of single-phase and three-phase systems for rural electrification schemes and comparative economic studies.
7. Guide for conversion of single-phase into three phase systems.
8. Guide for economic selection of transformer size.
9. Specification drawings of wood pole lines and its construction.
10. Specification and drawings for 11 kV line construction.
11. Specification and drawings for 11 kV and 400 volt line (HT/LT) construction.
12. Specification and drawings for 66, 33 & 22 kV line construction.
13. Specification and drawings for 66/33/22/11 kV sub-station construction and methods for determination of capacity and economic size of transformers.
14. Specification of line construction contracts.
15. Specification of sub-station construction contracts.
16. Guide for engineers for checking line and sub-station contracts.
17. Guide for making an operation and maintenance survey of transmission and distribution systems.
18. Guide for repairs of distribution transformers, switches, meters, etc.
19. Guide for voltage and current measurement on rural distribution system.
20. Guide for energy meters.
21. Guide for pole numbering and maintenance.
22. Guide for complete engineering, design and construction of rural electrification schemes.
23. Guide for design of civil construction works for different types of soils and rocky areas.
24. Guide for design and construction of service lines to consumer installations.

Some of the specific suggestions concerning certain major aspects of designs which could economise in the rural electrification schemes are noted hereafter:

I. RURAL LINES

(a) *Supports*

The type of supports used for the rural lines varies from State to State, PCC, RCC, steel structural section, second hand rails poles, wood poles, jointed wood poles, fabricated poles etc. are used according to the availability. It is high time that one or two types which are most economical are adopted and should be easily made available.

(b) *Spans*

.........It is, therefore, recommended that the maximum possible span, say, upto 130 metres, in all the areas should be employed as far as practicable.

(c) *Conductros*

.........Only economic standard sizes of ACSR after proper system study and optimisation should be adopted.

(d) *Insulators and Fittings*

.........research and experiments may be conducted to evolve a most economical type of insulator for rural areas..............11 kV pin insulators with 540 kg. failing load as per IS would

suffice. As regards disc insulators, insulators with minimum strength of 4500 kg as per IS specification would be sufficient.

(e) *and Others.*

II. 11/0.4 kV SUB-STATION

The following suggestions are made in this regard:

(a) Some State Electricity Boards are using economical type of gang-operating switches. These switches are at present being made for a rating of 200 amperes. The full load current of a 100 kVA transformer at 11 kV is about 5.5 amperes; of course, the fault current will be much higher......... The State Electricity Boards may install some percentage of the sub-stations with the simplified gang-operating switches as above and gain experience. The method can then be further extended.

(b) Omission of 11 kV lightning arresters from transformers, sub-stations upto 50 kVA in all the regions and upto 100 KVA in areas with low isoceraunic level. Instead arresters may be installed only at strategic points.

(c) Use of transformers with low iron loss and high copper loss. This will help in keeping the losses low as the load factor is very low in rural areas.

(d) ....it was decided that the use of 25 kVA 50/63 kVA and 100 kVA transformers should be standardised as this would help in considerable reduction of manufacturing costs.

(e) Installation of transformers of capacities to match with the anticipated loads in only the next 2 to 3 years and avoiding installation of large capacity transformers as far as possible.

(f) The low tension switch should be installed on the sub-station structure itself to economise on the length of low tension cables.

Technical Note II(1)

(Referred to in Chapter II)

NOTE ON CONVERSION FACTORS USED FOR AGGREGATION OF ENRGY MEASURES

The Energy Survey of India Committee keeping in view the particular problems of the Indian energy economy adopted the coal replacement method (also known as the total substitution method) by which each type or source of energy is measured in terms of the coal it replaces, when both the original source and the coal are used in appliances or equipment, and with the thermal efficiencies that are likely to be used in practice. The methodology used by the Energy Survey Committee for determining conversion factors of oil and electricity, the reasons for their adoption and the assumptions involved therein are extensively discussed by them on pages 322—329 of their Report vide Annex 5.

2. Briefly, (a) one tonne of coal is taken as one tonne of coal irrespective of its calorific value; (b) in the case of oil products—

(i) the cooking efficiency of kerosene is calculated on the assumption that calorific value is 11,000 kcal per kg and thermal efficiency is 51 per cent; as soft coke is assumed to have a calorific value of 5770 kcal per kg its thermal efficiency in an oven is 18 per cent. One unit of kerosene can replace 5.7 units of soft coke; as each unit of soft coke is produced from 1.5 units of coal to be produced, the coal replacement value of kerosene is 8.3;

(ii) in the case of HSDO, the actual performance of the Indian Railways in 1960-61 showed that for moving a unit of goods in the Indian Railways, the coal required is 9 times the diesel required. Based on this, the Energy Survey Committee has used a coal replacement ratio of 9 for HSDO and IEC. The Report of the Expert Committee on Coal Consumption in Railways in 1953 estimated the varying ratios of coal consumption in steam locomotives to oil consumption in diesel locomotives to be 8:1. The recent statistical information of the coal and diesel consumed in the Indian Railways indicates that this ratio may be more than 9:1. However, the Fuel Policy Committee for the sake of continuity retained the use of 9:1 is the coal replacement for HSDO. LDO goes into different uses where the relative efficiencies vary widely. However, the coal replacement ratio of 9 for LDO adopted by the Energy Survey Committee has been retained;

(iii) in the case of fuel oil, the efficiency of use in the furnaces is the same whether the fuel oil or coal is used. The calorific value of coal is taken as 5000 kcal per kg and that of fuel oil as 10,000 kcal per kg. The coal replacement ratio for fuel oil is taken as 2.

(c) in the case of electricity, the coal replacement has been measured by the Energy Survey Committee in terms of the total value of coal and oil used in thermal power stations in terms of one unit of electricity to be sold. In other words, the auxiliary consumption and transmission losses are accounted for in coal replacement measure (pages 3 to 7 of the Energy Survey Committee Report). It may be argued that the coal replacement measure should be calculated with reference to the energy generated but the Committee felt that the concept established by the Energy Survey Committee can be continued. Based on this, the coal replacement measures for electricity of one kg per kWh, one million tonnes of coal for one billion kWh of thermal energy has been assumed. This slightly improves over times as indicated in the Table below:—

	1971-72 (actual)	1978-79	1983-84	1990-91
1. Total energy generated by steam power stations (b. kWh) ..	31·24	74	115	224
2. Consumption by auxiliaries and losses in transmission etc. (b. kWh) ..	8·22	16·2	24·4	47·5
3. Net energy consumed (b. kWh)	23·02	57·8	90·6	176·5
4. Total consumption of coal and lignite (m. tonnes) ..	19·20	50	76	139
5. Oil consumption in terms of coal replacement (m. tonnes)	2·64	2·96	4·60	8·96
6. Total coal consumption (m tonnes)	21·84	52·96	80·60	147·96
7. Coal consumption per kWh of energy consumed ..	0·945	0·916	0·890	0·840

Note:—For the years 1978-79, 1983-84 and 1990-91, consumption of oil in thermal Power Stations has been assumed as 0·02 kg per kWh of energy generated keeping in view that the Thermal Power Stations in future would operate at greater efficiencies and higher plant factor thereby reducing the oil consumption which is required for flame stabilization when plants are operated at lower load factors. The committee has adopted 1·00 kg coal consumed per kWh of energy utilised for the sake of continnity.

In the case of non-commercial energy, the amounts of each non-commercial fuel required to replace a tonne of coke and the amount of coal required to make that coke, the ratios were arrived at by the Energy Survey Committee with data furnished by the C.F.R.I. The ratios are as follows;

tonne of soft coke ..	requires for manufacture coke-1·50 tonnes of coal.
1 tonne of dried dung	replaces 0·27 tonnes of soft coke-0·40 tonnes of coal.
1 tonne of firewood ..	replaces 0·0·65 tonnes of soft coke-0·95 tonnes of coal.
1 tonne of waste products	replaces 0·63 tonnes of soft coke-0·95 tonnes of coal.

Technical Note II(2)

(Referred to in Chapter II)

NOTES ON REGRESSION MODELS RELATING ENERGY REQUIREMENTS TO VARIOUS EXPLANATORY VARIABLES

1 Dependent Variables

1. Energy from Coal consumption for energy (mtcr).
2. Oil consumption for energy (mtcr).
3. Electricity (mtcr), and
4. Total commercial energy (mtcr).

2. Explanatory Variables

1. National income ('00 crores).
2. Income from Mining and Manufacturing ('00 crores).
3. Index of Industrial Production.

3. The Models

Linear regression models relating each of the dependent variables to each of the explanatory variables were developed, and regressed for the year 1953-54 through 1970-71. A set of log linear models was also developed.

S. No.	Dependant variable	Independent variable	Linear Model
1.	Coal ..	National Income	Y—7·5400+0·3594X
2.	Oil ..	,,	Y—653375+0·8487X
3.	Electricity ..	,,	Y—46·3375+0·4994X
4.	Commercial Energy	,,	Y—119·1636+1·7071X
1.	Coal ..	Income from Mining & Manufacturing	Y—7·5992+1·7679X
2.	Oil ..	,,	Y—252314+3·4889X
3.	Electricity ..	,,	Y—22·8506+2·0579X
4.	Total Commercial Energy ..	,,	Y—40·6454+7.1127X
1.	Coal ..	Index of of Industrial production	Y—13·0565+0·2612X
2.	Oil ..	,,	Y—14·8408+0·6006X
3.	Electricity ..	,,	Y—16·6603+0·3537X
4.	Total Commercial Energy ..	,,	Y—18·4128+1·2152X

4. The Results

The results from the linear models are briefly tabulated below:—

Dependent variable	Independent variable	Square of linear Cor. Coeff. (r2)	Standard Error S	Durbin-Watson Statistics
1. Coal ..	National Income	·877	·0336	1·235
2. Oil ..	,,	·973	·0352	1·671
3. Electricity ..	,,	·966	·0233	1·171
4. Total Commercial Energy ..	,,	·975	·0679	1·998
1. Coal ..	Income from Mining and Manufacturing	·955	·0848	1·846
2. Oil ..	,,	·941	1·291	0·344
3. Electricity ..	,,	·939	·1316	0·280
4. Total Commercial Energy ..	,,	·969	·3204	0·464
1. Coal ..	Index of Industrial Production	·924	·0188	1·224
2. Oil ..	,,	·971	·0260	0·388
3. Electricity ..	,,	·966	·0166	0·389
4. Total Commerical Energy ..	,,	·985	·0378	0·743

Since results with linear models were considered better (in terms of r^2) than the results with log-linear model, the log-linear results have not been presented. Some multiple regressions using tional income, population and index of industrial production were also attempted. While these models explained the past, trends slightly better; these could not be used for projection purposes in view of lack of reliable information on inter-sectoral growth rates.

Technical Note VIII(1)

REFINING CAPACITY, HYDROCRACKING CAPACITY AND FERTILIZER FEED-STOCK CHOICES: A MATHEMATICAL PROGRAMMING APPROACH

Programming Approach

Our approach to the problem of investment planning for petroleum industry has been to consider the feedstock choices, locational alternatives and refining process flexibilities simultaneously using a Mathematical Programming Model. The optimisation approach is broadly outlined below:

Given the spatial pattern of demand for petroleum products and nitrogenous fertilizers, the approach focusses attention on the following points:

(a) To determine the optimum level of refining capacity that ought to be established in the country. Also, to indicate the foreign exchange implications and community trade pattern under various alternatives open to the economy.

(b) To suggest the optimum regional distribution of refining capacity and quantify the impact of locational decisions.

(c) To indicate how the limited technological flexibility in refining operations could be increased by considering the addition of hydrocracking capacity at existing refineries as well as new locations.

(d) To bring out the inter-dependence of investment and operating decisions in the petroleum industry and the nitrogenous fertilizers industry. More specifically, to find out the best technological mix for the fertilizer industry indicating what proportion of nitrogen output be based on each of the available feedstock.

MATHEMATICAL PROGRAMMING MODEL

Various formulations of this programming approach have been considered.* Realistic considerations regarding the spatial aspects of the problem have increased the dimensions to about 325 constraints and 2800 choice variables. Because of computational reasons, the Linear Programming version has been used for empirical estimates.

Various activities of the linear Programming Version are : Imports of petroleum products (M^k_{pj}), refining of crude to yield various products (X_i^t), transportation of these products from refineries to demand points (X^k_{ij}), exports of products (E^k_{ip}), crude imports (F_{pi}), indigenous crude transportation (G_{si}), Hydrocracking of heavier fractions (X_i^{kh}), production of nitrogenous fertilizers (X_{ia}^{rf}) and transport of these fertilizers from plants demand points (X^f_{ab}). Each one of these activities has a corresponding cost parameter. The level at which each of these activities should operate is determined by minimising the sum of costs subject to the following constraints :—

> Petroleum Products Requirements, Fertilizer Demand, Fertilizer Demand and Supply Balances, Refinery Product Balances, Crude Demand and Supply Balances, Indigenous Crude availability, Port Capacity Constraints and the Non-negativity Constraints.

The mathematical formulation of the model, along with variables and parameters can be presented as below:—

There are :—

K	Petroleum product	..	k=1,2......K(5)
J	demand points for petroleum products	..	j=1,2......J(11)
P	Ports for imports ..	..	p=1,2......P(10)
I	refineries	..	i=1,2......I(13)
S	sources of indigenous crude	..	s=1,2......S(2)
A	supply locations for nitrogenious fertilifizer	..	a=1,2......A(31)
R	techniques available for production of nitrogenous fertilizers	..	r=1,2......R(3)
B	demand points for nitrogenous fertilsizers ..	..	b=1,2......B(30)

(Small letters denote parameters ; Capital letters denote variables)

AND

y^k_{pj} denotes, for the kth product, the c.i.f. price plus transport cost per unit from pth port to jth demand point.

M^k_{pj} is quantity of kWh product imported at pth port and transported to jth demand point.

c_i is the unit refining cost, inclusive of capital charges, for ith refinery.

X_i is quanfity of crude processed at ith refinery.

t^k_{ij} is unit transport cost for kth product from ith refinery to jth demand point.

X^k_j is quantity of kth product shipped from ith refinery to jth demand point.

W^k_{ip} is the profit (negative cost) for exporting kth product from ith refinery through port p.

E^k_{ip} is quantity exported from ith refinery of kth product through port p.

f_{pi} is C.I.F. import price of crude at pth port plus transport cost from pth port to ith refiners per unit.

F_{pi} is quantity of crude imported at ith refinery through port p.

q_{si} is unit transport cost for crude from sth source to ith refinery.

G_{si} is quantity of crude shipped from s to i.

h_i is unit cost of hydro-cracking.

X_i^{kh} is the quantity of heavier fraction (kth product) used as charge into the hydrocracker at refinery i.

C_a^{rf} is the per tonne cost of producing nitrogenous fertilizers (in terms of nutrient N) at location a using rth technique.

X_{ia}^{rf} is quantity of N produced at location a getting raw materials from refinery i and using the technique r.

t_{ab}^{f} unit cost of transport of N fertilizers from location a to demand point b corrected for difference of material.

X_{ab}^{f} quantity of N-fertilisers transported from supply location a to demand point b'

r_{j}^{k} is quantity of kth petroleum product required at jth demand point.

n_{b} is the quantity of N required at fertilizer demand point b.

a_{i}^{k} is the yield coefficient of kth petroleum product at ith refinery (i.e., it denotes the proportion f kth product per unit of crude processed at refinery i).

Q_{ia}^{rf} is the quantity of naphtha required per tonne of N for production technique r at supply location a using naphtha from ith refinery.

b_{i}^{k} is yield coefficient for kth product per unit of feed used in the hydro-cracker at ith refinery.

ϕ_{ia}^{rf} is the quantity of fuel oil required per tonne of N for production technique rat supply location a using fuel oil from ith refinery.

g_{s} is the quantity of crude Produced at indigenous source location s.

h_{i}^{kh} is the coefficient representing requirement of heavy-stock per unit of hydro-cracking feedstock.

OBJECTIVE FUNCTION

$$Z = \sum_{p,j,k} Y^{b}_{pj} \; M^{k}_{pj} + \sum_{i} c_i X_i + \sum_{i,j,k} t^{k}_{ij} X^{k}_{ij} - \sum_{i,p,k} w^{k}_{ip} \; E^{k}_{ip} + \sum_{p,i} f_{pi} \; F_{pi} + \sum_{i,s} q_{si} \, G_{si} + \sum_{i} h_i \, X^{kh}_{i} +$$
$$\sum_{a,r} C^{rf}_{a} \; X^{rf}_{ia} + \sum_{a,b} t^{f}_{ab} \; X^{f}_{ab}$$

CONSTRAINTS

1. Petroleum Products Requirement $\sum_{p} M^{k}_{pj} + \sum_{i} X^{k}_{ij} \geq r^{k}_{j}$ for all J & k

2. Fertilizer Demand $\sum_{a} X^{f}_{ab} \geq n_b$ for all b

3. Fertilizer Demand and Supply $\sum_{i,a} X^{rf}_{ia} - \sum_{b} X^{f}_{ab} \geq 0$ for all a

4. Fertinery Products Balances :

(a) k=1 NAPHTHA, M.S. $\sum a^{k}_{i} \; X^{k}_{i} - \sum_{j} X^{k}_{ij} - \sum_{p} E^{k}_{ip} - \sum_{r} \phi^{rf}_{ia} \; X^{rf}_{ia} + b^{k}_{i} \; X^{kh}_{i} \geq 0$ for all i

(b) k= 2 KS, 3 HSDO, 4 LDO $\sum a^{k}_{i} \; X^{k}_{i} - \sum_{j} X^{k}_{ij} - \sum_{p} E^{k}_{ip} + b^{k}_{i} \; X^{kh}_{i} \geq 0$ for all i

(c) k = 5 FO $\sum a^{kk}_{i} \; X^{k}_{i} - \sum_{j} X^{k}_{ij} - \sum_{p} E^{k}_{ip} - \sum \phi^{rf}_{ia} X^{rf}_{ia} - X^{kh}_{i} \; X^{kh}_{i} \geq 0$ for all i

5. Crude Demand and Supply Balances $-X_i + \sum_{p} F_{pi} + \sum_{s} G_{si} \geq 0$ for all i

6. Indigenous Crude Availability $-\sum_{i} G_{si} \geq g_s$ for all s

7. Non-Negativity constraints $M^{k}_{pj}, \; X_i \; X^{k}_{ij}, \; E^{k}_{ip}, \; F_{pi}, \; G_{si} \; X^{kh}_{i}, \; X^{rf}_{ia}, \; X^{f}_{ab} \geq 0$ for all p, j, k, i, s, a, b.

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